Psychopathology and positive emotions in daily life

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In this short review, we describe recent trends from Ecological Momentary Assessment (EMA) research investigating positive affect (PA) in relation to mood disorders. Aside from notable exceptions (e.g. mania), most mood disorders involve relatively lower levels of PA in daily life, often combined with a larger level of variability in PA. In reaction to positive events, studies show a puzzling ‘mood brightening’ effect in individuals with mood disorder symptoms that suggests hyper responsiveness to real-life rewards. Studies into anhedonia (i.e. lack of, or lower levels of PA) suggest that high-arousal PA and anticipatory PA are potential targets for intervention. Despite PA-focused EMA-interventions bear promises of greater therapeutic effectiveness, so far, these promises have not materialized yet.

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Introduction

In mood disorders feelings or emotions are distorted or inconsistent with its context to such an extent that it interferes with one’s ability to function [1]. Mood disorders include Bipolar Disorder, Dysthymia, Cyclothymic Disorder, Premenstrual Dysphoric Disorder, and Major Depressive Disorder (MDD), and affect approximately 10% of the population each year [2,3]. Research on affective psychopathology is predominantly focused on stress and Negative Affect (NA). In recent years, however, there has been increasing attention and recognition that rewarding experiences and Positive Affect (PA), or the lack thereof (i.e. anhedonia), is at least equally important for the understanding, treatment of, and recovery from, mood disorders.

PA generally refers to the experience of pleasurable emotions, such as happiness, relaxation, enthusiasm, and joy, and varies over time as a function of subjectively appraised context [4,5]. When it comes to understanding the nature of PA in the context of people’s daily life, Ecological Momentary Assessment (EMA) studies have examined the level of PA, its fluctuations, and interaction with contexts in both healthy and clinical populations. EMA is a structured diary technique to sample subjective experiences, behavior and context in the flow of daily life, typically using smartphone technology. Its naturalistic approach ensures ecologically valid data (i.e. generalizable to real-life). Participants typically fill out structured diaries multiple times a day (e.g. five times a day), that are assessed at fixed or random time points, and across multiple consecutive days (e.g. for 30 days). The high frequency in longitudinal sampling enables researchers to shed light on the nature of mood disorders on the micro-level. For example, to what extent depression is linked to PA changes across minutes or hours, and the extent to which these short-term changes in PA co-vary with behavior or other contextual factors over time. In addition, compared to retrospective questionnaires that asks patients to report on symptoms during the past weeks or months, the frequent sampling in EMA studies reduces recall bias. In that sense, EMA methods can not only validate diagnostic criteria in daily life, but also go beyond by providing novel insights into the micro-processes and mechanisms of mood disorders.

In what follows, we review some of the most important advancements of EMA research in PA and psychopathology over the last five years.

Positive Affect (PA) in daily life

In EMA studies, PA is typically operationalized as the mean of a set of adjective rating scales. For example, participants are asked ‘How do you feel at the moment?’ followed by the adjectives ‘relaxed’, ‘happy’, and ‘cheerful’ and a slider-scale anchored with ‘not at all’ (outer left) and ‘very much’ (outer right). Often, but not always, the set of affective items is based on the Positive Affect and Negative Affect Schedule [6], or is based on circumplex models of affect [7,8] with the selection made to balance high and low arousal items [9]. The most frequently used adjectives used to describe PA in EMA research in relation to mood disorders over the last two years are feeling relaxed, happy, and cheerful (see Figure 1).

Figure 1

The Ecological Momentary Assessments (EMA) items used to assess Positive Affect, extracted from 17 EMA studies that reported on PA and mood disorders between 2018 and June 2020. Number on the X-axis reflects number of studies that used the EMA-item depicted on the Y-axis. We searched in Web of Science (WoS) Core Collection electronic database for English-language papers published between 2018 and June 2020 using the following key terms: 'positive emotion' OR 'positive affect' OR 'positive mood' OR 'pleasure' OR 'well-being' OR 'eudaimon'; and 'Mood disorder' OR 'Affect' disorder OR 'Bipolar' OR 'Bipolar Disorder' OR 'Depress' OR 'Major Depressive Disorder' OR 'MDD' OR 'anhedonia'; and 'Experience sampling' OR 'Ecological Momentary Assessment' OR 'Experience Sampling Method' OR 'structured diary method' OR 'intensive longitudinal assessment' OR 'real-time data capture study' OR 'event sampling' OR 'beeper study' OR 'ambulatory study' in title, abstract, author keywords, and Keywords Plus. From the 90 articles, 24 were marked as relevant because they (1) explicitly or implicitly handled the subject of positive affect or anhedonia; (2) had a focus on mental health or mood disorder, and (3) used EMA. We excluded studies that focused on (1) genetics, or neurological underpinnings; (2) methodological studies; and (3) studies that did not report on PA items, leaving 17 recent EMA studies for extraction of PA items.

EMA studies have linked compromised mental health and mood disorders to various alterations in PA functioning, such as reduced PA complexity and PA flexibility in daily life [10], blunted PA reactivity to daily life stress ([11]) and reduced expectations of future PA (Note: when having a history of depression, but not bipolar disorder; [12]). The most robust finding, however, is the consistent link between lower psychological well-being or increased mood disorder symptomatology and lower mean levels of PA [10,12,13,14,15,16,17^{**},18,20]. One exception should be noted though, namely in the manic phases of bipolar disorder, which manifests as (too) high levels of PA.

PA dynamics in mood disorders

In addition to the robust link between mood disorders and lower mean level is PA in daily life, EMA researchers explored the link between mood disorders and the dynamic nature of PA. PA dynamics are quantitative descriptions of PA summarizing how PA unfolds and fluctuates over time. For example, emotional variability, operationalized as the average within-person variance in affect or average within-person Standard Deviation (SD) in affect, summarizes the dispersion in PA levels. In addition, there are more complex affective dynamics such as inertia (i.e. auto-correlation or auto-regression coefficient; summarizes how self-predictive affect is over time),

and the Mean Successive Squared Difference (MSSD; summarizes how unstable affect is over time). For a visual illustration of these dynamics, see [Figure 2](#).

Recent EMA studies report paradoxical results in this respect. Whereas some studies found no association between PA dynamics and mood disorders [14,17^{••}], others have linked symptoms of mood disorders and low psychological well-being to greater variability in PA ([15] in high-arousal PA; first study of [16,19,21^{••}]), and/or more inert PA [16,22,23]. In the meta-analyses on the relation between affect dynamics and psychological well-being, lower well-being was characterized by both greater variability and inertia irrespective of ESM time frame [16]. However, this inertia-variability paradox is resolved when taking the overlap among the mean, variability, and inertia into account (i.e. by controlling for one or the other). Indeed, although PA dynamics are interrelated, the differences between groups in the level of variability (e.g. variance) and the level of inertia (e.g. autocorrelation) in PA are typically examined in isolation. EMA research on negative affect and wellbeing suggests that, when adjusted for the overlap, inertia adds little predictive value in the prediction of mood disorders over and above the lower level of PA and larger spread in PA levels ([24,25[•],26]; see also [Figure 2](#)).

In people with bipolar disorder, after controlling for differences in individuals' mean PA, variability in PA still provides unique and additional information [19,21^{••}]. However, over-and-above the PA mean and variability, the auto-correlation of PA (inertia) likely adds limited information in predicting psychological health [25[•]].

Real-life reward responsiveness and mood brightening

The Emotion Context Insensitivity theory and positive attenuation hypothesis predict attenuated emotional reactivity to positive emotional stimuli in the daily lives of depressed individuals [27]. In line with this hypothesis and theory, depression is consistently associated with reduced reward responsiveness in experimental studies and neurological studies in the laboratory [28–31]. In stark contrast, results from EMA studies show either no differences in depressed individuals' reward responsiveness, or evidence for the opposite: a 'mood brightening effect', defined as a greater improvement in the mood of depressed individuals in the hours after they report having experienced a positive event.³

³ It should be noted that one recent EMA study reported reduced reward responsiveness in depressed individuals, but, instead of the change in PA after pleasant activities or events, reward responsiveness was operationalized as the pleasantness rating of daily activities [61], better known as appraisal.

The first report of the mood brightening effect concerned a larger decrease in NA and larger increase in PA after positive events in depressed versus non-depressed individuals [32]. Most EMA studies thereafter predominantly focused on the brightening in NA (e.g. Ref. [33]). Although in stark contrast to theory and empirical results from the laboratory, the mood brightening effect in PA seems robust and, compared to anxiety, specific to depression — with more severely depressed individuals showing greater brightening [34[•]]. Interestingly, anticipating next-day positive events seem to produce similar mood brightening effects [35].

So far, several factors have been excluded as the driving force behind the mood brightening effect [36]. First, the scarcity in positive events that is often observed in depressed patients (i.e. contrast hypothesis). Second, the lower threshold to appraise positive events as positive and, third, floor effects in PA that may create relatively larger room for improvement in the PA of depressed individuals. Perhaps, emotion regulation might (partly) explain mood brightening effects. For NA, depressed individuals' tendency to ruminate (i.e. focused attention to negative events and moods) might be lowered by the experience of a positive event to an extent that they ruminate less than controls, and the subsequent lower level of NA presents itself as a mood brightening effect [33].

Another explanation for the discrepancy between theory and EMA results on reward responsiveness could be that PA reactivity to the self-reported pleasantness of an event is a suboptimal operationalization. Bakker *et al.* [37] argued that experimental tasks and behavioral activation therapy typically involve approach-based rewards, suggesting that situations in which one can encounter relatively many rewards (e.g. engaging with friends, working or being physically active; hereafter 'active behavior') is a better operationalization or translation of rewards in daily life than (pleasantness ratings of) positive events. Remarkably, when operationalizing reward responsiveness in daily life as PA reactivity to active behavior, in line with theory, the authors indeed observe a blunted reward responsiveness in individuals with depressive symptoms. However, the new operationalization is still awaiting replication. Heininga *et al.* [14] explored both operationalizations of reward responsiveness in the daily lives of depressed patients and healthy controls, but found no difference between both groups in PA reactivity to positive events, nor in PA reactivity to active behavior.

Anhedonia in daily life

To better understand PA in mood disorders, it may also be useful to shift the focus from syndromes to symptoms [38]. Anhedonia is one of the two core symptoms of depression and is clinically understood as 'a markedly diminished interest or pleasure in all, or almost all,

Figure 2

Hypothetical example of how PA unfolds over time in individuals with mood disorder versus healthy controls. Based on individual patient data from Heininga *et al.* [14].

activities of the day' during the past two weeks [1]. Based on advances in neurology and experimental psychology, anhedonia is now understood as impairments in the ability to experience reward (i.e. deficit in 'liking'; consummatory anhedonia), pursue reward (i.e. deficit in 'wanting'; anticipatory anhedonia) and/or learn about reward ([39–42]; but see Ref.: [43]).

With regard to 'liking' in daily life, anhedonia is linked to lower appraisal of positive events (i.e. positive events are rated less pleasurable; [15]; but see Ref.: [20]), fewer positive event experiences [20], and lower levels of PA in daily life [14,15,20,44]. Beyond these descriptive statistics, anhedonic versus non-anhedonic individuals also show differences in their associations between events and PA over time. Consummatory high-arousal PA (e.g. feeling 'energetic', 'enthusiastic', and 'cheerful') might be of special interest to better understand anhedonia, as individuals with anhedonia show 'mood brightening' in high-arousal PA but not low-arousal PA [15], and show a diminished favorable impact on affective experiences in individuals with anhedonia [44]. That is, compared to healthy controls, high-arousal PA in individuals with anhedonia is typically followed by a greater increase in NA and stress, and a greater decrease in PA and physical activity approximately six hours later (see Figure 3).

With regard to 'wanting', EMA studies suggest that alterations in motivation and anticipation might also be a vulnerability marker for mood disorders. For example, low PA in anhedonia is associated with lower levels of motivation six hours later [45], and the results suggest that

individuals with anhedonia are at risk for a negative spiral of low PA and low motivation. Furthermore, depressive symptoms are also linked to diminished anticipatory pleasure experiences [46], and a weaker link between anticipatory pleasure and active behavior [37]. Together, these EMA advances suggest that, in addition to a lower mean level of PA, individuals with depressive symptoms are less able or less motivated to modify their daily behaviors as a function of reward anticipation.

With regard to deficits in reward learning in the daily lives of individuals with anhedonia, advances show that the EMA timeframe is key. Without conscious processing, individuals learn about the reward value of each context and activity by creating associations with co-occurring rewarding experiences such as PA. These implicit associations, in turn, increase the likelihood that individuals engage in similar contexts and activities semi-randomly assessed approximately 90 min later and the next day [47]. However, such associative learning effects were not replicated when using a short-term retrospective ESM design with fixed beeps approximately six hours apart [48]. More EMA research is thus needed to determine the optimal design to investigate reward learning in daily life.

PA-focused daily life interventions

Given that the one-size-fits-all treatment approach is not always effective, EMA Interventions (EMIs) have been put forward as a promising tool to personalize affective disorder treatments and improve their effectiveness (e.g. Refs. [49–52]). So far, three EMIs have been developed that focus on PA and (symptoms of) mood disorders.

Figure 3

Adapted from Figure 2 of Bos *et al.* [44]. Networks of anhedonic and non-anhedonic individuals showing the strength of the IRF associations estimated through automated impulse response function analysis (IRF). Green (solid) arrows indicate positive associations between variables; red (dashed) arrows negative ones. The stronger a particular association, the thicker and brighter the color of the arrow.

In the first Randomized Controlled Trials (RCT) ESM-I study, depressive symptoms were effectively reduced by six weekly sessions of ESM-based PA-feedback [53]. The feedback purely descriptive, for example, graphically showing patients' own level of PA across different situations. A follow-up study revealed that the decrease in depressive symptoms was preceded by a decrease in sedentary behaviors and an increase in physical activity and social behaviors [54], suggesting that lifestyle changes may be part of the remedy. It should be noted though that, although patients' depressive complaints reduced according to the Hamilton Depression Rating

Scale and the Inventory of Depressive Symptoms, according to the EMA assessments, patients' momentary levels of PA did not change during the intervention [55].

Next, beyond mere descriptive feedback, van Roekel *et al.* [20,56,57] showed that evaluative feedback in the form of ESM-based recommendations on how to change one's lifestyle might be a more effective way to reduce depressive symptoms – at least in a sub clinical sample. Albeit effect sizes were small, and participants showed no marked decrease in depressive symptoms according to the Patient Health Questionnaire, self-monitoring in

Figure 4

Upper part: adapted Figure 3b from Kramer *et al.* [53]. Lower part: adapted Figure 2 from Appendix D from Bastiaansen *et al.* [60**]. Plots show predicted lines plotted across time (intention-to-treat analysis). IDS = Inventory of Depressive Symptomatology. Post-EMA = assessment in the week after the 28-day intervention period. FU = Follow Up assessment. In the study of Bastiaansen *et al.* [60**], during the 28-day intervention period, patients received weekly feedback on either positive affect and activities (Do-module; experimental 1) or negative affect and thinking patterns (Think-module; experimental 2).

combination with specific recommendations for lifestyle changes effectively increased participants' PA levels throughout daily life, suggesting evaluative feedback may also be an effective way to augment the efficacy of regular depression treatment. In line with these findings, indeed, recent advances on Behavioral Activation treatments suggest that these treatments may work by targeting (low) reward responsiveness directly [42,58].

Finally, Bastiaansen *et al.* [59,60**] translated these findings to clinical practice by providing both descriptive and evaluative Behavioral Activation based feedback on patients' PA, but found no evidence for improvements compared to patients' PA who followed treatment as usual, nor evidence for an increase in EMI-specific empowerment or social functioning of patients. When comparing the study of Bastiaansen *et al.* to the study of

Kramer *et al.* (Figure 4), the largest difference is in the control groups of both studies (i.e. treatment as usual). Whereas in Kramer's study the treatment as usual was medication which only marginally improved patients' moods, in the study of Bastiaansen *et al.*, treatment as usual consisted of medication combined with psychotherapy which was more effective in improving patients' moods in the control group. Although the PA-focused EMI did not go beyond the efficacy of medication and psychotherapy, Bastiaansen *et al.*, conclude that it may be worthwhile to investigate whether EMIs can be blended with routine mental health services as they have the potential to make psychotherapy treatments more time-efficient for therapists without sacrificing efficacy.

Conclusions

Recent advances in the field of Positive Affective (PA) and mood disorders in daily life suggest that people with mood disorders typically experience relatively lower levels of PA in daily life, possibly combined with a reduced anticipatory PA, and moment-to-moment variability in PA in bipolar disorder. Future EMA studies into mood disorders may benefit from incorporating both consummatory PA (as experienced in-the-moment) and anticipatory PA (looking forward to future activities or contexts). Social contexts, stress and motivation seem closely related to PA in the daily lives of individuals with anhedonia, and unravelling its underlying mechanisms may be an important next step in fine-tuning treatments for mood disorder.

Evidence from laboratory settings versus EMA appears paradoxical, as laboratory studies show blunted reward responses in depression, whereas EMA studies show evidence for the opposite (i.e. a 'PA brightening effect' in response to positive events). To reconcile both strands of literature, future studies may benefit from a more in-depth analysis into the type of positive events, as well as the operationalizations of reward responsiveness in daily life. For example, by exploring possible relevant differences in the types of positive events (e.g. intrapersonal/interpersonal events, or social/non-social events), and PA reactivity to positive events active behavior, while also including reward-related laboratory test batteries in the same EMA study participants. That way, reward responsiveness in daily life could be 'calibrated' by comparing correlational patterns. Another promising direction for future research would be to investigate the moderating effects of PA regulation strategies on PA brightening after positive events and/or active behavior.

Although the promised therapeutic efficacy of EMIs has not fully materialized (yet), PA-focused EMIs that aim to alter behavior in daily life seem a cost-effective and easily accessible alternative for patients who cannot receive standard Behavioral Activation therapy, or not yet. Furthermore, EMIs may help to understand the mechanisms

that underlie behavioral change in Behavioral Activation treatment. There are indications that future PA-focused EMIs may be most effective when targeting both consummatory and anticipatory PA as well as the strength of the connection between both, and involve a type of evaluative feedback which is preferably integrated with face-to-face therapist guidance sessions.

Conflict of interest statement

Nothing declared.

CRediT authorship contribution statement

Vera E Heininga: Conceptualization, Investigation, Visualization, Data curation, Writing - original draft, Writing - review & editing. **Peter Kuppens:** Conceptualization, Writing - review & editing.

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- of outstanding interest

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