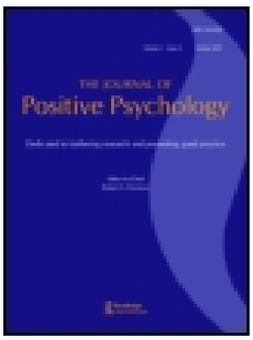

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Reciprocal relationships between State gratitude and high- and low-arousal positive affects in daily life: A time-lagged ecological assessment study

Lilian Jans-Beken[a], Nele Jacobs[a,b], Mayke Janssens[a,b], Sanne Peeters[a,b], Jennifer Reijnders[a], Lilian Lechner[a] and Johan Lataster[a,b]

[a]Faculty of Psychology and Educational Sciences, Open University, Heerlen, The Netherlands; [b]Department of Psychiatry and Psychology, School for Mental Health and Neuroscience, Maastricht University Medical Centre, Maastricht, The Netherlands

ABSTRACT

This study assessed whether state gratitude and high and low-arousal positive affect show reciprocal relationships in daily life, and whether these relationships are dependent of inter-individual differences in positive mental health or psychopathology. 106 participants reported on momentary gratitude and positive affects throughout 7 consecutive days, using the Experience Sampling Method. Multilevel time-lagged regression analyses showed that state gratitude, cheerfulness and satisfaction reciprocally predict one another from one moment to the next. The strength of the prospective relationships between state gratitude(t-1) and both cheerfulness (t) and satisfaction(t) did not vary as a function of inter-individual differences in positive mental health or psychopathology. However, the prospective effects of both cheerfulness(t-1) and satisfaction(t-1) on state gratitude(t) were significantly stronger for individuals with low vs. high levels of psychopathology. In addition, the prospective effect of cheerfulness(t-1) on state gratitude(t) was significantly stronger for those with high vs. low positive mental health.

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Ecological Momentary Assessment; ESM; diary; grateful; active affect; deactive affect; psychopathology; positive mental health; flourishing; depression

Positive emotions are considered to serve a vital role in optimal human functioning, fostering physical health, subjective well-being, and psychological resilience (Fredrickson, 2001). Out of all positive emotions, gratitude has been forwarded as particularly potent due to its capacity to build a variety of enduring personal and social resources (Armenta, Fritz, & Lyubomirsky, 2016; Fredrickson, 2004b), with beneficial impacts on various domains of health and well-being (Wood, Froh, & Geraghty, 2010). Gratitude has been conceptualized on a trait and state level (Wood, Maltby, Stewart, Linley, & Joseph, 2008). Trait gratitude refers to the overall tendency to feel and express grateful feelings when obtaining positive outcomes (McCullough, Emmons, & Tsang, 2002), and a wider life orientation towards noticing and being grateful for the positive in the world (Wood et al., 2010). State gratitude, or 'the grateful emotion' (McCullough, Tsang, & Emmons, 2004), refers to a temporary affect with associated thought and action tendencies (Clore, Ortony, & Foss, 1987; Rosenberg, 1998; Wood et al., 2008). The grateful emotion arises when appraising a received benefit as a positive outcome and recognizing that the source of this positive outcome lies outside the self (Emmons & Crumpler, 2000; Teigen, 1997; Tsang, 2006). The present study zooms in on the momentary, state level of gratitude, and its relation to other positive emotional states in daily life.

The broaden-and-build theory (Fredrickson, 2001) explains how positive emotions, such as gratitude, can initiate an upward spiral towards positive mental health, set in motion by their 'broadening' effect on momentary thought-action repertoires. In contrast to negative emotions, which tend to *narrow* our behavioural repertoire towards immediate survival (Cannon, 1929; Selye, 1946), positive emotions evoke a tendency to 'let our guard down', characterized by *broadened* thought and action patterns (e.g. playing, exploring) that intuitively seem to lack immediate survival value (Fredrickson, 2004a). However, the broaden-and-build theory suggests that positive emotions have survived as part of human experience because their broadening effect enables us to build durable personal resources – e.g. social play builds social bonds, exploration builds knowledge (Fredrickson, 2001, 2004a; Panksepp, 2001), with indirect benefits for survival in the long run. A distinction has been made between high- and low-arousal positive emotional states (e.g. *excitement* vs. *contentment*; Fredrickson & Branigan, 2005; Russell, 1980), and attentional broadening may be especially pronounced in low arousal contexts (Gable & Harmon-

CONTACT Lilian Jans-Beken info@lilianjansbeken.nl

Jones, 2010). Previous work has categorized gratitude as a low-arousal (Cavanaugh, MacInnis, & Weiss, 2016), and as an other-directed or empathic positive emotion (Tugade, Shiota, & Kirby, 2014). The broadening effects of gratitude include the encouragement of prosocial behaviour toward and beyond benefactors, increased creativity regarding the expression of gratitude (e.g. conveying love and appreciation), and improved quality of reciprocity beyond simple 'tit-for-tat' responses (Fredrickson, 2004a). These thought-action tendencies promote our personal well-being and that of others and help in forming lasting relationships and friendships through reciprocal responsiveness (Canevello & Crocker, 2010). The broadening effects of gratitude as a low-arousal emotion, thus, are thought to contribute to the building of valuable resources on the personal, social, and societal level (Fredrickson, 2004b), ultimately fostering human resilience and sustaining positive mental health (Wood et al., 2010).

A key implication of the broaden-and-build theory is that positive emotions, through their broadening effects on thought and action, will increase the likelihood of finding positive meaning in subsequent events, in turn promoting future positive emotional states (Fredrickson & Joiner, 2002). Prospective correlational and daily-diary studies indeed show that the experience of positive emotions is related to future positive emotional experiences over the course of months (Burns et al., 2008), weeks (Fredrickson & Joiner, 2002), and from one day to the next (Garland, Geschwind, Peeters, & Wichers, 2015). However, although emotional phenomena are generally short-lived and momentary in nature (Fredrickson & Branigan, 2005; Reeve, 2014), it remains unclear whether positive emotions also tend to engage in self-sustaining cycles throughout a single day, and, more specifically, whether gratitude interacts reciprocally with other positive emotional states at the level of momentary, daily life experience.

The broaden-and-build theory implies, secondly, that reciprocal relationships of positive emotions represent an important resilience mechanism (Tugade & Fredrickson, 2004), contributing positively to the presence of positive mental health and the absence of psychopathology (Garland et al., 2015), and vice versa. This is partly evidenced by Catalino and Fredrickson (2011), showing that 'flourishers' – i.e. individuals with optimal levels of subjective well-being – tend to react with more positive emotion to everyday pleasant events than 'non-flourishers' and depressed individuals, suggestive of a 'positive potentiation process' involved in human flourishing. However, use of the retrospective Day Reconstruction Method (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004) in their study did not allow to capture moment-to-moment affective dynamics, and may have, additionally, induced recall bias (Talarico, Berntsen, & Rubin, 2009). Moreover, Catalino and Fredrickson (2011) did not focus specifically on the positive emotion of gratitude.

Therefore, in order to further our scientific knowledge about the value of everyday high- and low-arousal positive emotions and state gratitude, the current study used the Experience Sampling Method (ESM; Csikszentmihalyi & Larson, 2014), a structured ecological assessment technique, to prospectively obtain a fine-grained, high resolution film of the moment-to-moment ('micro-level'; Kramer, 2015) dynamics of state gratitude and other positive emotional states as they play out in daily life. Using the ESM, we investigated (i) whether momentary states of gratitude and high- and low-arousal positive affect tend to be reciprocally associated in daily life, and (ii) whether such reciprocal relationships of positive emotional states, at the micro-level of daily life experience, are connected to inter-individual differences in macro-level positive mental health and psychopathology phenotypes. Based on broaden-and-build theory, it was hypothesized that state gratitude and both high- and especially low-arousal positive affect would reciprocally and prospectively predict one another from one moment to the next, and that this reciprocal relationship in daily life would be stronger for individuals with relatively high vs. low levels of positive mental health, as for individuals with relatively low vs. high levels of psychopathology.

Methods

Sample

The sample consisted of 126 Dutch speaking adults from the general population, recruited by graduate students of the Open University of the Netherlands through personal contact and online social media. Study entry criteria were (i) aged 18+ years, and (ii) sufficient command of the Dutch language to understand instructions and provided informed consent. The study was approved by the local research ethics committee and was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for medical research involving humans. Participation in the study was voluntary and all participants gave digital informed consent after being fully informed about the study and having had the opportunity to have any questions answered.

Of the 126 participants that entered the study, 20 were excluded from analyses due to insufficient valid ESM-reports (see Experience Sampling Method). The

final study sample, thus, consisted of 106 participants (M_{age} = 39, SD_{age} = 15, range 18 – 65) among which 43 men (41%), that completed on average 46 (68%) out of 70 diary assessments (*SD* = 12; *Min* = 23, *Max* = 70), resulting in a total of 4,870 observations. Further sample characteristics are presented in Table 1.

Procedure

Participants were first requested to fill out a one-time online questionnaire asking them about demographic information, positive mental health, psychopathology, and trait gratitude. After having filled out the online questionnaire, participants received an instruction to install a mobile application (RealLife™ Exp, vers. 2.4.8; Lifedata, 2015) on their smartphone that was used to prospectively collect Experience Sampling data during seven consecutive days. Participants were additionally provided with a telephone number that they could call if assistance was desired at any point during the study; some participants contacted the researcher for assistance with installation of the mobile application. After having completed the Experience Sampling protocol, participants were debriefed about the study and received an electronic thank you card.

Experience sampling method

The Experience Sampling Method (ESM) is a well-validated structured diary technique to assess participants' thoughts, feelings, and (the appraisal of) contexts in everyday life (Delespaul, 1995; Hektner, Schmidt, & Csikszentmihalyi, 2007; Jacobs et al., 2005; Myin-Germeys et al., 2009). The RealLife Exp mobile application that was used to collect Experience Sampling data, was programmed to signal at an unpredictable moment in each of ten 90-min time blocks between 7:30 a.m. and 22:30 p.m., on seven consecutive days, with signals separated by a minimum of 30 and maximum of 150 minutes. At each prompt, participants were presented with a number of items they had to rate, collecting reports of affect, gratitude, current context, and appraisal thereof. The number of items was kept to a minimum to reduce the likelihood of participant fatigue and attrition (Bolger, Davis, & Rafaeli, 2003; Thiele, Laireiter, & Baumann, 2002). Participants were instructed to complete their reports immediately after the signal but definitely within 15 minutes of the signal, thus minimizing memory distortion. When a participant did not respond within 15 minutes to a signal, the signal expired and was no longer accessible to the participant. Previous work has shown that reports completed after this interval are less reliable (Delespaul, 1995). For the same reason, subjects with less than 23 valid reports (one-third (33⅓%) of 70 signals in total) were excluded from analyses (Delespaul, 1995).

Table 1. Sample characteristics.

	Total sample
N (%)	106 (100)
Age *M* (*SD*)	39 (15)
[range]	[18–65]
Gender *n* (%)	
• Men	43 (41)
• Women	63 (59)
Relationship status *n* (%)	
• Single	30 (28)
• In a relationship	76 (72)
Household *n* (%)	
• Living with underage children	35 (33)
• Not living with underage children	71 (67)
Education level *n* (%)	
• Elementary school	2 (2)
• Lower vocational education	11 (10)
• Intermediate vocational education	17 (16)
• Pre-university education	21 (20)
• Bachelor's degree	42 (40)
• Master's degree or higher	13 (12)
Employment status *n* (%)	
• Full-time	52 (49)
• Part-time	37 (35)
• Unemployed or retired	17 (16)

Note. *M* = mean, *SD* = standard deviation

Measures

Momentary emotional states

Based on previous ESM studies (Jacobs et al., 2007; Myin-Germeys & van Os, 2007; Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006; Wichers et al., 2009), momentary affect was assessed with positive and negative affect scale measures, each consisting of scores on several items derived from the Positive And Negative Affect Schedule (PANAS; Engelen, de Peuter, Victoir, van Diest, & van den Bergh, 2006; Watson, Clark, & Tellegen, 1988). Items were selected to assess a broad range of affect across the dimensions of 'valence' (positive – negative) and 'arousal' (high – low) (Kuppens, Tuerlinckx, Russell, & Barrett, 2013). The presence of negative affect may counteract or attenuate reciprocal relationships of positive emotions (Garland et al., 2015), and was therefore assessed alongside positive affect. In addition, this provided participants with a balanced set of positively and negatively valenced items at each prompt, thus minimizing likelihood of emotional reactivity in any specific direction.

Positive affect was assessed with scores on the items 'I feel cheerful', for high-arousal positive affect, and 'I feel satisfied', for low-arousal positive affect, at each momentary report, rated on a 7-point Likert scale with a range of 1 (*not at all*) to 7 (*very*). Overall negative affect was defined as the mean score on the items 'I feel

insecure', 'I feel anxious', 'I feel down', and 'I feel guilty' for each momentary report, rated on a 7-point Likert scale with a range of 1 (*not at all*) to 7 (*very*). (Cronbach's $\alpha_{(within)}$ = .64; Cronbach's $\alpha_{(aggregated)}$ = .95).

State gratitude

In accordance with previous measurements of daily gratitude (DeWall, Lambert, Pond, Kashdan, & Fincham, 2012; Emmons & McCullough, 2003; Visserman, Righetti, Impett, Keltner, & van Lange, 2017), we assessed state gratitude using the single-item measure 'I feel grateful', rated on a 7-point Likert scale (1 = *not at all* to 7 = *very*).

Positive mental health

We used The Mental Health Continuum Short Form (MHC-SF; Keyes, 2002; Lamers, Westerhof, Bohlmeijer, Ten Klooster, & Keyes, 2011a) to measure positive mental health once at the start of the study. The questionnaire consists of 14 questions that tap into the presence of different aspects of emotional (e.g. '…did you feel satisfied with life?'), psychological (e.g. '… did you feel that your life has a sense of direction or meaning to it?'), and social well-being (e.g. '… did you feel that you belonged to a community?') during the past month, answered on a 6-point Likert scale (1 = *never* to 6 = *every day*). The mean score represents the overall level of positive mental health, with higher scores indicating higher levels of positive mental health. The psychometric properties of the Dutch MHC-SF are good: Cronbach's α = .89 (Lamers et al., 2011a), and α = .93 in the current study sample.

Psychopathology

The Symptom Questionnaire 48 (SQ48; Carlier et al., 2012), presented once at the start of the study, measures 48 symptoms of psychopathology across a number of domains (aggression, agoraphobia, anxiety, cognitive problems, depression, somatization, social phobia, overall lack of vitality, and work-related stress). Participants were asked how often each symptom (e.g. 'I felt down or depressed') was present during the past week, and indicated their response on a 5-point Likert scale (0 = *never* to 4 = *very often*). As suggested by Carlier et al. (2012), items from the work subscale of the SQ48 may not be reliably answered by unemployed participants, and were therefore omitted. The mean score of the remaining subscales represents the overall level of psychopathology, with higher scores indicating more symptoms of psychopathology. The psychometric properties of the SQ48 are good; α = .94 – .97 (Carlier et al., 2015, 2012), and α = .95 in the current study sample.

Trait gratitude

Gratitude as an affective trait has been linked to both increased and decreased grateful reactivity to positive events (McCullough et al., 2004), thus possibly influencing the affective dynamics under examination. Trait gratitude was, therefore, assessed once at the start of the study with the Dutch version of the Gratitude Questionnaire (GQ6; Jans-Beken, Lataster, Leontjevas, & Jacobs, 2015; McCullough et al., 2002). The questionnaire consists of six propositions, and participants rated their response to each proposition (e.g. 'I have so much in life to be thankful for') on a 7-point Likert scale, ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Two negatively formulated items were reverse coded, and the mean score across the six propositions was used as indicator of trait gratitude, with higher scores indicating a higher level of trait gratitude. The psychometric properties of the Dutch GQ6 are considered good (Jans-Beken et al., 2015), with Cronbach's α = .72 in the current study sample.

Statistical analyses

Given the prospective study design and hypotheses, and hierarchical structure of the data, i.e. multiple measurements (level 1) clustered within individuals (level 2), multilevel time-lagged regression analyses were conducted using the 'LAG' (*t-1*) and 'MIXED' (mixed linear model) commands in SPSS version 24.0 (IBM Corp, 2016). Lagged (*t-1*) values were constructed for all observations, except for those representing the last response of a day, to not allow for lags between values from two different days. To facilitate interpretation of level 1 associations and cross-level interactions, level 1 predictors were centred around each individual's mean, and level 2 predictors and covariates measured on a continuous scale were standardized based on the grand mean and standard deviation (Curran & Bauer, 2011; Enders & Tofighi, 2007; van de Pol & Wright, 2009). All analyses were a priori corrected for the demographic factors age, gender (0 = male; 1 = female), and education level (0 = low – intermediate vocational education or lower; 1 = high – pre-university education or higher), given their previously established association with gratitude (Jans-Beken, Lataster, Peels, Lechner, & Jacobs, 2017) and affect regulation (Zimmermann & Iwanski, 2014). We additionally adjusted for predispositions towards gratitude by adding mean scores on the GQ6 as level 2 covariate. Reciprocal level 1 associations between feeling grateful, cheerful and satisfied were further adjusted for the possible confounding influence of overall negative affect (hereafter: NA) at time *t*. All models included a variable representing time (sampling days 1 to 7) to account for assessment reactivity, and a lagged (*t-1*) version of the outcome variable, to

correct for first-order autoregression. Level 1 intercepts and associations were allowed to vary randomly across individuals at level 2 (Snijders, 2005), and the level 2 intercept and slope represent the average level 1 intercept and slope across individuals. Significance was interpreted against a threshold of $p = .05$.

First, to examine whether momentary states of gratitude (hereafter: SG), cheerfulness, and satisfaction showed reciprocal associations over time, we ran four models: Model 1 tested whether SG(*t – 1*) was a significant predictor of cheerfulness(*t*). Model 2, reversely, tested whether cheerfulness(*t – 1*) was a significant predictor of SG(*t*). Model 3 tested whether SG(*t – 1*) was a significant predictor of satisfaction(*t*). Model 4, reversely, tested whether satisfaction(*t – 1*) was a significant predictor of SG(*t*).

Next, positive mental health and psychopathology were added separately as level 2 moderators to all four models, resulting in Models 5 through 12: Models 5 and 7 tested whether levels of positive mental health (Model 5) and, resp., psychopathology (Model 7) moderated the association between SG(*t – 1*) and cheerfulness(*t*). Models 6 and 8 tested whether levels of positive mental health (Model 6) and, resp., psychopathology (Model 8) moderated the association between SG(*t – 1*) and satisfaction(*t*).

Models 9 and 11 tested whether levels of positive mental health (Model 9) and, resp., psychopathology (Model 11) moderated the association between cheerfulness(*t – 1*) and SG(*t*). Models 10 and 12 tested whether levels of positive mental health (Model 10) and, resp., psychopathology (Model 12) moderated the association between satisfaction(*t – 1*) and SG(*t*).

Significant interactions were followed up with visualisations, depicting associations between level 1 variables for separate moderator strata (mean ± one standard deviation) (Whisman & McClelland, 2005).

Results

Means, standard deviations and correlations of the aggregated measures for momentary positive high arousal affect (cheerful), positive low arousal affect (satisfied) and overall negative affect, gratitude (state and trait), positive mental health and psychopathology are presented in Table 2.

Reciprocal prospective associations between momentary gratitude and positive affects in daily life

The models assessing reciprocal associations between SG and positive affects revealed significant overall effects of both SG(*t-1*) on cheerfulness(*t*) ($B = .073$, $p < .001$, 95% CI [.031, .115], Model 1), and cheerfulness(*t-1*) on SG(*t*) ($B = .066$, $p = .002$, 95% CI [.025, .107], Model 2): higher levels of SG were followed by higher levels of cheerfulness and vice versa. In addition, significant effects of both SG(*t-1*) on satisfaction(*t*) ($B = .094$, $p < .001$, 95% CI [.047, .142], Model 3), and satisfaction(*t-1*) on SG(*t*) were observed ($B = .075$, $p < .001$, 95% CI [.033, .117], Model 4): higher levels of SG were followed by higher levels of satisfaction and vice versa, see Table 3. We additionally observed significant between-subject variation in intra-individual associations between NA(*t*) and cheerfulness(*t*) ($B = -.597$, $p < .001$, 95% CI [-.713, -.481]), NA(*t*) and satisfaction(*t*) ($B = -.656$, $p < .001$, 95% CI [-.736, -.549]) and NA(*t*) and SG (*t*) ($B = -.470$, $p < .001$, 95% CI [-.567, -.373]). Autoregressive associations were found for cheerfulness ($B = .149$; $p < .001$, 95% CI [.099, .198]), satisfaction ($B = .124$; $p < .001$, 95% CI [.075, .172]), and SG ($B = .185$, $p < .001$, 95% CI [.134, .236]).

Moderating effects of positive mental health on reciprocal prospective associations between momentary gratitude and positive affects in daily life

Model fit for the cheerfulness(*t*) model did not improve significantly with addition of the SG(*t-1*)*positive mental health interaction term ($\chi^2_{Change}(2) = 1.490$, $p > .05$). Positive mental health did not prove to be a significant moderator of the association between SG(*t-1*) and cheerfulness(*t*) ($B = -.014$, $p = .455$, 95% CI [-.051, .023], Model 5):

Table 2. Means, standard deviations and Pearson's correlation matrix of the measures GQ6, MHC-SF, SQ48, NA scale, Cheerful, Satisfied, State gratitude.

Measure	*N*	*M* (*SD*)	1	2	3	4	5	6	7
(1) GQ6[a]	106	5.500 (0.791)	-						
(2) MHC-SF[b]	106	2.890 (0.969)	.475	-					
(3) SQ48[c]	106	1.025 (0.509)	-.354	-.523	-				
(4) NA scale[a]	107	1.761 (0.785)	-.308	-.463	.596	-			
(5) Cheerful[a]	107	4.763 (1.036)	.326	.429	-.352	-.490	-		
(6) Satisfied[a]	107	5.047 (0.936)	.327	.548	-.490	-.606	.795	-	
(7) State gratitude[a]	107	4.855 (1.056)	.383	.511	-.353	-.366	.671	.775	-

Note. *M* = mean, *SD* = standard deviation. All correlations significant at .01 level (one-tailed) [a] measured on a 7-point Likert scale (1–7) [b] measured on a 6-point Likert scale (1–6) [c] measured on a 5-point Likert scale (0–4)

Table 3. Results of multilevel analyses assessing reciprocal associations between cheerful, satisfied, and state gratitude at the micro-level of everyday life.

	Cheerful (*t*)			Satisfied (*t*)			State gratitude (*t*)			State gratitude (*t*)		
	B (*SE*)	95% CI	*p*	*B* (*SE*)	95% CI	*p*	*B* (*SE*)	95% CI	*P*	*B* (*SE*)	95% CI	*P*
Fixed effects												
Age	.294 (.093)	.110, .479	.002	.114 (.085)	-.055, .284	.183	.141 (.093)	-.043, .324	.131	.141 (.092)	-.043, .324	.131
Gender	.407 (.192)	.026, .789	.037	.075 (.177)	-.275, .426	.672	.301 (.192)	-.079, .681	.119	.294 (.191)	-.085, .674	.127
Education level	-.353 (.210)	-.769, -.064	.096	-.491 (.193)	-.874, -.109	.012	-.517 (.209)	-.932, -.102	.015	-.520 (.209)	-.934, -,105	.015
Trait gratitude	.319 (.096)	.128, .509	.001	.356 (.088)	.181, .531	< .001	.435 (.096)	.246, .652	< .001	.437 (.096)	.248, .627	< .001
Time	-.028 (.008)	-.044, -.012	< .001	-.033 (.008)	-.048, -.017	< .001	-.018 (.008)	-.033, -.003	.019	-.018 (.008)	-.033, -.003	.022
Cheerful (*t-1*)	.149 (.025)	.099, .198	< .001				.066 (.021)	.025, .107	.002			
Satisfied (*t-1*)				.124 (.024)	.075, .172	< .001				.075 (.021)	.033, .117	< .001
State gratitude (*t-1*)	.073 (.021)	.031, .115	< .001	.094 (.024)	.047, .142	< .001	.185 (.026)	.134, .236	< .001	.178 (.025)	.127, .228	< .001
Negative affect (*t*)	-.597 (.057)	-.713, -.481	< .001	-.656 (.054)	-.763, -.549	< .001	-.470 (.048)	-.567, -.373	< .001	-.468 (.049)	-.565, -.371	< .001
Random effects												
Negative affect	.147 (.056)	.070, .309	.008	.125 (.039)	.068, .232	.001	.088 (.032)	.043, .180	.007	.089 (.033)	.043, .183	.007
Cheerful	.025 (.007)	.014, .045	< .001				.010 (.005)	.004, .027	.044			
Satisfied				.019 (.007)	.010, .040	.006				.008 (.005)	.002, .028	.134
State gratitude	.005 (.005)	.001, .034	.295	.016 (.007)	.007, .038	.021	.026 (.008)	.014, .049	.002	.023 (.008)	.012, .045	.003

Note. (t) = current signal; (*t* - 1) = previous signal; *B* = regression coefficient; *SE* = standard error; CI = confidence interval. Age standardized based on grand mean and standard deviation. Gender (0=male; 1=female). Education level (0=low; 1=high). Time = sampling days 1-7. Level 1 predictors centred around individual mean.

Table 4. Results of interaction analyses assessing reciprocal associations between cheerful, satisfied, and state gratitude dependent of levels of positive mental health and psychopathology.

	B(*SE*)	95% CI	*p*
Model 5: State gratitude(*t*-1) * PMH Cheerful(*t*)	-.014 (.019)	-.051, .023	= .455
Model 6: State gratitude(*t*-1) * PMH Satisfied(*t*)	.027 (.021)	-.015, .070	= .204
Model 7: State gratitude(*t*-1) * PSY Cheerful(*t*)	-.009 (.018)	-.045, .028	= .633
Model 8: State gratitude(*t*-1) * PSY Satisfied(*t*)	-.024 (.021)	-.066, .018	= .252
Model 9: Cheerful(*t*-1) * PMH State gratitude(*t*)	.044 (.018)	.008, .080	= .017
Model 10: Satisfied(*t*-1) * PMH State gratitude(*t*)	.023 (.019)	-.014, .061	= .215
Model 11: Cheerful(*t*-1) * PSY State gratitude(*t*)	-.070 (.019)	-.107, -.033	< .001
Model 12: Satisfied(*t*-1) * PSY State gratitude(*t*)	-.062 (.019)	-.099, -.024	= .002

Note. (*t*) = current signal; (*t* - 1) = previous signal; *B* = regression coefficient; *SE* = standard error; CI = confidence interval; PMH = positive mental health; PSY = psychopathology.

the association did not vary significantly between individuals with different levels of positive mental health.

Model fit for the SG(*t*) model improved significantly with addition of the cheerfulness(*t-1*)*positive mental health interaction term (χ^2_{Change} (2) = 25.688, $p < .001$), and revealed a significant moderating effect of positive mental health on the association between cheerfulness(*t-1*) and SG(*t*) ($B = .044$, $p = .017$, 95% CI [.008, .080], Model 9): individuals scoring relatively higher on positive mental health displayed a stronger association between cheerfulness(*t-1*) and SG(*t*) than those scoring relatively lower on positive mental health (see Figure 1 for visualization of the effect).

Although model fit for the satisfaction(*t*) model improved significantly with addition of the SG(*t-1*)*positive mental health interaction term (χ^2_{Change} (2) = 29.106, $p < .001$), positive mental health did not prove to be a significant moderator of the association between SG(*t-1*) and satisfaction(*t*) ($B = .027$, $p = .204$, 95% CI [-.015, .070], Model 6): the association did not vary significantly between individuals with different levels of positive mental health.

The model fit for the SG(*t*) model improved significantly with addition of the satisfaction(*t-1*)*positive mental health interaction term ($\chi^2_{Change}(2) = 17.314$, $p < .001$), but did not reveal a significant moderating effect of positive mental health on the association between satisfaction(*t-1*) and SG (*t*) ($B = .023$, $p = .215$, 95% CI [-.014, .061], Model 10): the association did not vary significantly between individuals with different levels of positive mental health.

Moderating effects of psychopathology on reciprocal prospective associations between momentary gratitude and positive affects in daily life

The model fit for the cheerfulness(*t*) model did not improve significantly with addition of the SG(*t-1*)*psychopathology interaction term ($\chi^2_{Change}(2) = 4.502$, $p = .105$). No significant moderating effect was found of psychopathology on the association between SG(*t-1*) and cheerfulness(*t*) (B = -

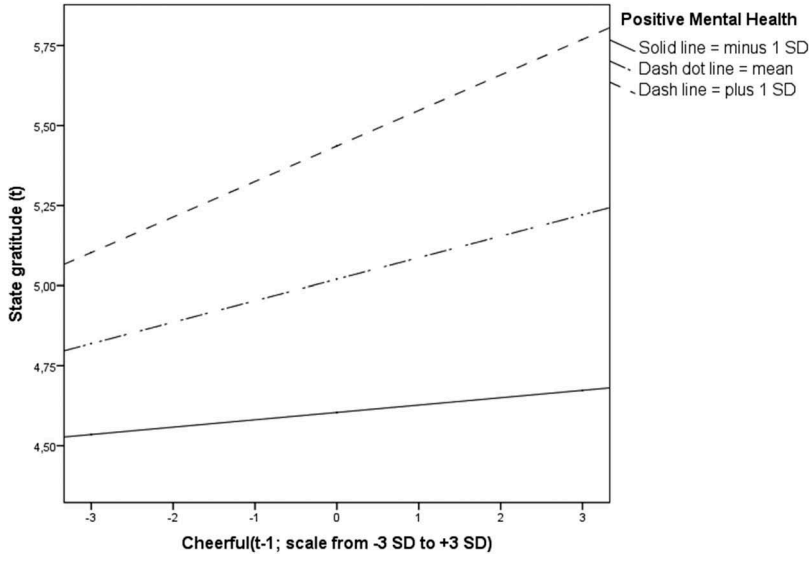

Figure 1. Interaction model Cheerfulness * Positive Mental Health and State Gratitude (Model 9).

.009, $p = .633$, 95% CI [-.045, .028], Model 7) the association did not vary significantly between individuals with different levels of psychopathology.

Adding the interaction term cheerfulness(*t-1*)*psychopathology to the model of SG(*t*) yielded improved model fit ($\chi^2_{Change}(2) = 26.086$, $p < .001$), and identified psychopathology as a significant moderator of the association between cheerfulness(*t-1*) and SG(*t*) (B = -.070, $p < .001$, 95% CI [-.107, -.033], Model 11): individuals scoring relatively higher on psychopathology displayed a weaker association between cheerfulness(*t-1*) and SG(*t*) than those scoring relatively lower on psychopathology (see Figure 2 for visualization of the effect).

Although the model fit for the satisfaction(*t*) model improved significantly with addition of the SG(*t-1*)*psychopathology interaction term ($\chi^2_{Change}(2) = 30.612$, $p < .001$), psychopathology did not prove to be a significant moderator of the association between SG(*t-1*) and satisfaction(*t*) ($B = .024$, $p = .252$, 95% CI [-.066, .018], Model 8) the association did not vary significantly between individuals with different levels of psychopathology..

The model fit for the SG(*t*) model improved significantly with addition of the satisfaction(*t-1*) *psychopathology interaction term ($\chi^2_{Change}(2) = 19.488$, $p < .001$), and revealed a significant moderating effect of psychopathology on the association between satisfaction(*t-1*) and SG(*t*) ($B = .062$, $p = .002$, 95% CI [-.099, -.024], Model 12): individuals scoring relatively higher on psychopathology displayed a weaker association between satisfaction(*t-1*) and SG(*t*) than those scoring relatively lower on psychopathology (see Figure 3 for visualization of the effect).

Discussion

The aim of this study was to assess whether momentary states of gratitude and positive high arousal and positive low arousal affect are reciprocally associated in daily life, and whether such reciprocal relationships of positive emotions, at the micro-level of daily life experience, are connected to macro-level positive mental health and psychopathology phenotypes. Our daily-life ESM data – prospectively collected using a mobile application and analysed with multilevel time-lagged regression techniques – show that state gratitude, cheerfulness and satisfaction, as hypothesized, reciprocally predict one another from one moment to the next with small effects. Secondly, the strength of the positive prospective relationships between state gratitude(*t-1*) and both cheerfulness(*t*) and satisfaction(*t*) did not vary as a function of inter-individual differences in positive mental health and psychopathology. The reverse positive prospective effects of both cheerfulness(*t-1*) and satisfaction(*t-1*) on state gratitude(*t*), however, were significantly stronger for individuals with relatively low vs. high levels of psychopathology. In addition, the positive prospective effect of cheerfulness*(t-1)* on state gratitude*(t)* was significantly stronger for individuals with relatively high vs. low positive mental health, whereas the positive prospective effect of satisfaction (*t-1*) on state gratitude(*t*) did not differ between individuals with different levels of positive mental health. These results lend partial support to our second hypothesis. Taken together, our findings support the idea that the positive emotional states of gratitude, positive high arousal affect cheerfulness, and positive

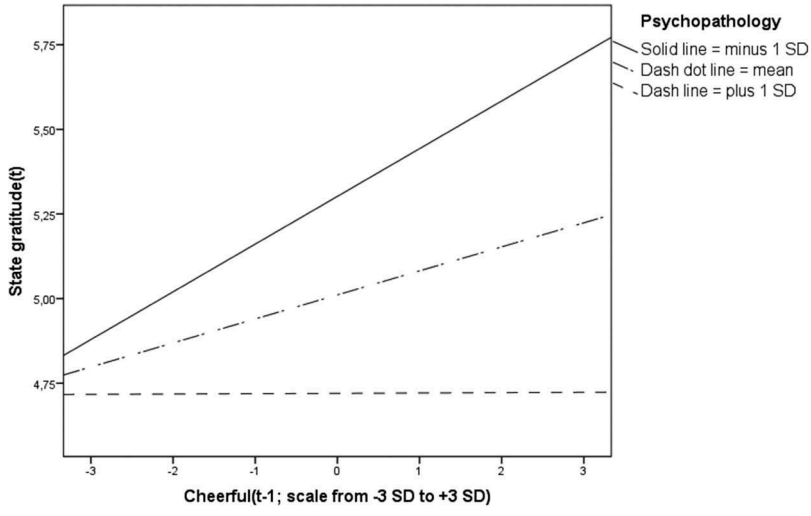

Figure 2. Interaction model Cheerfulness * Psychopathology and State Gratitude (Model 11).

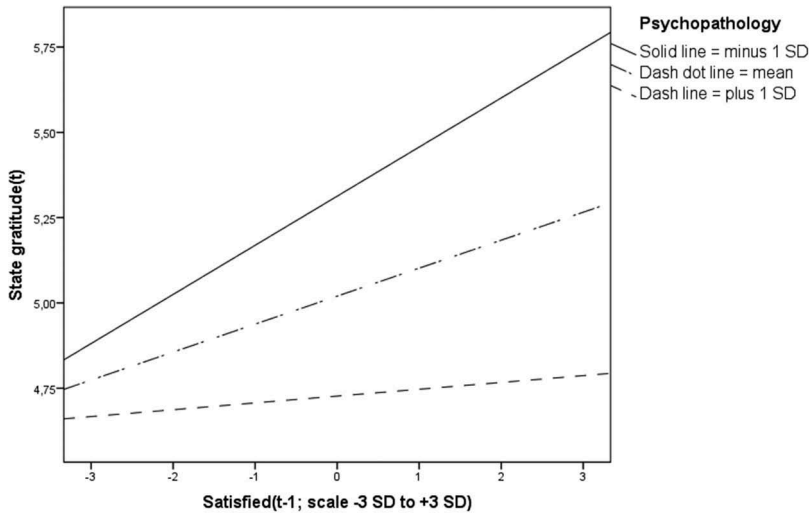

Figure 3. Interaction model Satisfaction * Psychopathology and State Gratitude (Model 12).

low arousal affect satisfaction, tend to be positively and reciprocally associated over time at the micro-level of daily life experience. Moreover, inter-individual differences in positive mental health and levels of psychopathology may be expressed in daily life as differences in the extent to which current high- and low-arousal positive affective states predict later state gratitude.

Reciprocal connections between state gratitude and high- and low-arousal positive affect in daily life

The current study was built on the premise that positive emotions – in particular low-arousal states – through their broadening effects on thought and action, increase the likelihood of finding positive meaning in subsequent events, thereby promoting positive emotional experience in the future (Fredrickson, 2003; Gable & Harmon-Jones, 2010). Although previous studies have already demonstrated temporal associations between positive emotional states over the course of months, weeks, and from one day to the next (Burns et al., 2008; Fredrickson & Joiner, 2002; Garland et al., 2015; resp.), our study shows that positive emotional states are temporally associated over the course of, on average, 90-minute intervals throughout the day. More specifically, the present study is the first to show bidirectional intra-individual associations between gratitude and both high- and low-arousal positive affects in daily life, extending previous work on day-level associations between gratitude and positive affectivity (Emmons & McCullough, 2003).

With regard to the moment-to-moment dynamics of gratitude and positive affects, the current findings are suggestive of small reciprocal relationships in daily life. The experience of positive affect may increase the likelihood of later gratitude through broadened thought-action patterns, encouraging the appreciation of what is positive, important and meaningful in future events (Lambert, Graham, Fincham, & Stillman, 2009). Although high-arousal states may momentarily attenuate attentional broadening (Gable & Harmon-Jones, 2010), our findings support the idea that both high- and low-arousal positive affects may foster a general state of thankfulness or appreciation as well as signifying experiences and benefits in the environment for which one can be grateful for (Lambert et al., 2009).

Our data also support the presence of a reverse path between gratitude and subsequent positive affects in daily life. In addition to feeling pleasant and enjoyable (Emmons & Mishra, 2011), gratitude as a low-arousal positive affect may orient attention to events or interactions that are stimulating and emotionally rewarding for the individual (Gable & Harmon-Jones, 2010), and gratitude-fueled desires of being a better person and helping others may eventually lead to self-improvement, more satisfactory relationships and associated well-being (Layous, Nelson, Kurtz, & Lyubomirsky, 2017). Previous work has suggested that gratitude may not necessarily lead to immediate positive affectivity, as the experience and expression of gratitude towards a benefactor may initially induce feelings of indebtedness, guilt and a general sense of discomfort (Armenta et al., 2016), as well as increasing efforts to assist the benefactor even when these are emotionally costly (Bartlett & DeSteno, 2006). Although our findings identified gratitude as a significant predictor of

subsequent high- and low-arousal positive affect in daily life, in spite of the presence of negative affect, future ecological assessment studies should further clarify the interplay of gratitude and both positive and negative affective states, as well as identifying cognitive and behavioural processes at play.

Prospective reciprocal associations between daily life high- and low-arousal positive affect and state gratitude as a function of inter-individual differences in positive mental health and psychopathology

Individuals with higher levels of positive mental health displayed, on average, stronger intra-individual prospective associations between daily life high-arousal positive affect and subsequent state gratitude than individuals with lower levels of positive mental health. This finding was not reducible to between-subject differences in predispositions towards gratitude, as these were accounted for in all statistical models. Our observations align with the idea that the positive mental health or 'flourishing' phenotype, in comparison to the 'non-flourishing' phenotype, may endorse increased salience towards positive experiences, as well as a stronger tendency to respond to these with thought-action patterns that highlight 'the good' in interaction with its environment, thereby facilitating personal resource building (Fredrickson, 2004a). In addition to experiencing stronger positive emotional reactivity to pleasant events, 'flourishers' have been shown to demonstrate mindful acceptance of distressing thoughts and feelings, and increased attentiveness to their internal and external surroundings, when compared to 'non-flourishers' and depressed individuals (Catalino & Fredrickson, 2011). Future studies may help to further elucidate to what extent these characteristics may underlie the observed stronger temporal association between daily life positive affective experiences and gratitude in individuals with relatively high vs. low positive mental health.

Although our global measure of psychopathology encompassed various domains of mental illness, the majority of items pertained to the symptom domains of mood and anxiety disorders. The currently observed weaker temporal associations between high and low-arousal positive affects and state gratitude in individuals with higher (vs. lower) levels of psychopathology fit previous reports of reduced capacity to generate and sustain positive emotions in individuals with depression (Geschwind et al., 2010; Heller et al., 2009; Wichers et al., 2009). In addition, the experience of positive affect and positive events in daily life has been shown to be attenuated by levels of anxiety in individuals with anxiety disorder (Kashdan & Steger, 2006), and neuroticism, a marker of general risk for psychopathology (Ormel et al., 2013), has been linked to a faster decay of positive emotions over time (Hemenover, 2003). The process of 'positive potentiation' – i.e. positive emotional sensitivity and (re)activity (Fredrickson, 2013b) – that is considered fundamental to the state of human flourishing may, thus, be less pronounced or absent in individuals with (risk for) psychopathology, in line with the present study findings. Previous observational and experimental research has shown, moreover, that mindful acceptance of emotional experiences appears to positively counteract reduced hedonic capacity, and partly restore reward experience in individuals with anxiety and depression (Geschwind, Peeters, Drukker, van Os, & Wichers, 2011; Kashdan & Steger, 2006). This is consistent with the broaden-and-build originated idea that being curious, open and accepting (i.e., mindful) towards internal and external events increases the likelihood of positive emotional experiences (Fredrickson & Joiner, 2002), whereas a lack of broadened thinking may hinder the ability to observe what is positive or beneficial, and consequently hampers the potential to evoke grateful emotions. Moreover, in addition to reduced positive potentiation, mood disorders in particular have been characterized by increased negative emotional sensitivity (O'Neill, Cohen, Tolpin, & Gunthert, 2004; Wichers et al., 2007), linked to the onset and persistence of depressive symptoms over time (Cohen, Gunthert, Butler, O'Neill, & Tolpin, 2005), and shown to interact with positive emotional experiences in daily life (Myin-Germeys et al., 2007). Although our analyses were adjusted for the influence of negative affectivity at the momentary level, temporal associations between positive emotional states in daily life are thus likely driven, in part, by the complex interaction of positive and negative potentiation tendencies, which may be affected in individuals with psychopathology.

Our data suggest that the prospective effect of state gratitude on high- and low-arousal positive affect in daily life is similar for individuals with different levels of positive mental health and psychopathology. As described above, gratitude may differ from other positive mood states in that it is an 'other-oriented', moral affect, encouraging prosocial efforts regardless of possible emotional consequences (positive or negative) thereof (Bartlett & DeSteno, 2006; Tugade et al., 2014; Weiner, Russell & Lerman, 1979). The broadening effects of gratitude may, therefore, manifest themselves in daily life predominantly at the (cognitive-)behavioural rather than emotional level, taking the form of prosocial

thoughts and acts that are in turn linked to human flourishing through social resource building (Fredrickson, 2004a; Nelson, Layous, Cole, & Lyubomirsky, 2016). Thus, although the experience of high or low-arousal positive affect following gratitude in daily life may not differentiate individuals with high vs. low levels of positive mental health or psychopathology, these individuals may differ in their tendency to respond to grateful experiences with prosocial thoughts and behaviours. As addressed above, replication and extension of the present study findings is therefore warranted in studies with additional attention to social behavioural and contextual factors. In addition, the current study deliberately took a broad perspective on positive mental health and psychopathology, but our findings give reason for further investigation of distinct dimensions of positive mental health and psychopathology in relation to high and low-arousal positive affect and state gratitude.

Implications

The findings of the present study show small but significant moment-to-moment associations between high and low-arousal positive affect and state gratitude in daily life. Previous daily and momentary assessment studies on affective dynamics have shown effects of similar size in daily life to possess clinical significance for e.g. depression (Wichers et al., 2010), anxiety (Farmer & Kashdan, 2014), addiction (Shiffman & Waters, 2004), and long-term physical health (Piazza, Charles, Sliwinski, Mogle, & Almeida, 2013; Sin, Graham-Engeland, Ong, & Almeida, 2015). The daily life prospective association between high and low-arousal positive affect and state gratitude, although small, may similarly represent a relevant mechanism for optimal human functioning, as supported by its tendency to vary in strength as a function of positive mental health and psychopathology. Although our findings could give rise to the interpretation that both high and low-arousal positive affect and state gratitude engage in a never-ending build-up of positive emotion that is bound to eventually go 'through the roof', it is important to bear in mind that only *on average*, a small positive association between subsequent high and low-arousal positive emotional states was found in daily life. Thus, high and low-arousal positive affect and state gratitude were not necessarily positively associated across *all* subsequent time-points in *all* individuals, nor did they linearly increase as the sampling week proceeded. Rather, our observations point towards a self-perpetuating cycle of various positive emotions in daily life that generates energy 'by itself', without necessarily gaining momentum beyond the equilibrium state in the absence of a potentiating stimulus.

Although our findings suggest temporal directionality, they do not imply causality, as our study did not include any experimental manipulation, such as the induction of gratitude and/or high and low-arousal positive affect. Any inference about cause and effect, based on the current findings, remains therefore highly speculative. However, although evidence for the efficacy of gratitude interventions on subjective well-being is currently weak (see Davis et al., 2016 for meta-analysis), experimental studies have demonstrated that inducing positive emotional experience, e.g. by loving kindness meditation, can set in motion a self-perpetuating flow of increased positive emotion (e.g. Kok et al., 2013). In addition, recent technological developments have opened up the avenue for low-threshold, personalized mHealth programs to enhance daily life positive emotions (van Os et al., 2017), with promising results in the field of depression (Kramer et al., 2014). Given the supposed interaction between positive and negative emotional spirals in daily life (Garland et al., 2015), interventions focusing on a more general, mindful acceptance of momentary emotional experiences (e.g. Batink et al., 2016), whether positive or negative, may be particularly potent for increasing daily-life emotional well-being. Care should be taken, however, to investigate to what extent such interventions are in line with an individual's background, interests, and motivation (Layous & Lyubomirsky, 2014), as this will likely predict their effectiveness.

Strengths and limitations

Our study has several strengths, most notably the use of an ecologically valid design with a considerable number of prospective assessments over a 7-day period, allowing to reliably capture moment-to-moment variations in daily life emotional experience without retrospective bias. Further strengths lie in the use of multilevel regression techniques to examine intra-individual associations, as well as inter-individual differences therein, and attention to confounding factors at trait and momentary levels of measurement. Nonetheless, the present study has some limitations that require consideration.

First, apart from considerable variation in age and gender, our participants represented a rather homogenous group of highly educated, working individuals in a relationship. Although all analyses were adjusted for the effects of demographic factors, the current study findings may nonetheless lack accuracy

regarding generalization to the population level. Non-representativeness of study samples is a common issue in behavioural science (Henrich, Heine, & Norenzayan, 2010), and future studies are advised to recruit representative samples that accurately reflect the population composition or focus on specific demographic groups and not generalize findings beyond them. Secondly, the sensitivity to detect inter-individual differences regarding the effect of state gratitude on subsequent high- and low-arousal positive affect may have been limited by a lack of variation in positive mental health and psychopathology in the present study sample, in addition to overall high mean levels of state gratitude and high- and low-arousal positive affect in daily life. However, this alone unlikely explains why prospective associations between state gratitude and subsequent high- and low-arousal positive affect were not found to vary between individuals with different levels of positive mental health and psychopathology (Models 5 to 8), given such inter-individual differences *were* detected with regard to the reverse associations between high- and low-arousal positive affect and subsequent state gratitude (Models 9, 11 and 12). Moreover, scores on positive mental health were overall comparable to norm scores reported previously by Lamers, Westerhof, Bohlmeijer, Ten Klooster, and Keyes (2011b); current study *M*(*SD*) = 2.89(.97) vs. norm score *M*(*SD*) = 2.98(.85). Third, the present study assessed state gratitude, cheerfulness, and satisfaction with single item measures. Although constructs are preferably measured with a number of items, questionnaire conciseness is crucial for increasing compliance and response reliability, and preventing attrition in ecological assessment studies (Bolger et al., 2003; Thiele et al., 2002). Moreover, a 1-item measure can be as effective as a multi-item scale when it is unambiguous and concrete (Bergkvist, 2015). Nonetheless, future ecological assessment studies may consider using more than one item to assess state gratitude and related constructs, in order to gain more insight in their cognitive-affective workings in everyday life. Fourth, the findings presented stem from multilevel models that took into account within-person clustering of data by conceptualizing multiple measurements (level 1) within individuals (level 2), but did not model additional within-day clustering of observations by adding a third level. However, two- and three-level models were compared systematically, and because model convergence was often problematic and model fit decreased substantially for all models when adding the day-level, we opted for omitting it, as was done in previous studies (e.g. Fazeli et al., 2017; Hartmann et al., 2015; Reininghaus et al., 2016). Fifth, our findings possibly lack accuracy since the exact time between lags was not taken into account, and future ESM studies are advised to consider continuous-time models to more precisely account for measurement intervals (De Haan-Rietdijk, Voelkle, Keijsers, & Hamaker, 2017). Sixth, the significant interaction-effect between cheerfulness*(t-1)* and positive mental health in the model of state gratitude*(t)* may represent a Type I error in the context of multiple testing. Seventh, although clear strengths of the ESM have been highlighted above, ecological assessment methods can be potentially burdensome and elicit reactivity in participants (Conner, Tennen, Fleeson, & Barrett, 2009). Response rates in the current study were similar to those typically observed in computerized signal-contingent ESM studies with multiple notifications per day (see e.g. Christensen, Barrett, Bliss-Moreau, Lebo, & Kaschub, 2003). Although we did, indeed, observe a slight decrease in positive affect during the sampling week at group level, this does not reflect reactivity per se, and in any case unlikely hampers interpretation of our findings, given all analyses were adjusted for the effect of sampling day. Lastly, future ESM-studies on emotional experience are advised to systematically monitor the occurrence of unexpected impactful events (positive and negative) during the sampling period, as these may be of impact on the emotional processes under investigation.

Conclusion

The present study adds to the existing literature on gratitude and other positive emotions by showing, for the first time, that state gratitude and high and low-arousal positive affect reciprocally predict one another at the micro-level of daily life experience: higher levels of state gratitude are followed by higher levels of both high and low-arousal positive affect and vice versa. Moreover, the positive prospective effect of state gratitude on both high and low-arousal positive affect was small, and similar for individuals with different levels of positive mental health and psychopathology. The prospective effect of both high and low-arousal positive affect on state gratitude, on the other hand, was shown to vary especially between individuals with different levels of psychopathology and, less convincingly, between individuals differencing in positive mental health. Although our results warrant replication, they suggest

that daily life dynamics of state gratitude and high and low-arousal positive affect are linked to optimal human functioning, and future studies are needed to further uncover the mechanisms at play.

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Declaration of interest

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Lilian Jans-Beken http://orcid.org/0000-0003-0647-5229
Lilian Lechner http://orcid.org/0000-0002-5160-7086
Johan Lataster http://orcid.org/0000-0003-3889-8154

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