Motivation and Emotion (2019) 43:285–298
https://doi.org/10.1007/s11031-018-9729-8

ORIGINAL PAPER

Testing the influence of negative and positive emotion on future health-promoting behaviors in a community sample

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Published online: 12 October 2018

Abstract
Adaptive behaviors, such as exercise and relaxation, are well-demonstrated to provide broad benefits, yet little is known about how emotion precede and/or influence their use. Broadly, literature suggests that adaptive health behaviors are enacted for the purpose of regulating negative affective experiences. However, other theoretical work suggests that positive affect precedes adaptive health behaviors, serving to maintain positive affective states. We sought to explicitly test the role of within-person fluctuations in negative and positive emotion in future adaptive behavior. Adults ($n=56$) who were either psychologically healthy ($n=22$) or diagnosed with major depression and/or social anxiety disorder ($n=34$) completed an in-lab diagnostic interview, followed by a 14-day experience sampling diary measuring within-person fluctuations in positive and negative emotion and health behaviors. Within-person levels of positive affect was significantly associated with future positive health behaviors. Prior positive behaviors was also significantly associated with behaviors reported in the next signal. Additionally, mean positive affect was significantly associated with engagement in positive health behaviors. There were no significant associations for within-person or mean negative affect, and there were no group differences. Together, these results support a maintenance model, such that within-person increases in positive affect predicted future report of positive health behaviors.

Keywords Emotions · Experience sampling · Health behaviors · Positive affect

Regulation versus maintenance?

Adaptive health behaviors such as exercise, social support seeking, and engaging in hobbies and/or relaxation activities are well-acknowledged to contribute to both physical and psychological health (Berger and Motl 2000; Holt-Lunstad and Smith 2012). Indeed, there is evidence suggesting that adaptive health behaviors appear to increase reports of positive affect and well-being (e.g., Maher et al. 2013; Sonnentag 2001) as well as influence broader biological systems underlying improvements in health (e.g., Bryan et al. 2007; Creswell et al. 2016). Thus, adaptive health behaviors can be defined as behaviors that promote both physical and psychological health. Despite the confluence of evidence demonstrating how these behaviors influence emotion, *there is little evidence demonstrating how emotions may influence these behaviors*. For example, for individuals who suffer from psychiatric disorders or high levels of psychological distress (due to environmental stress), adaptive health behaviors are thought to be enacted in the service of *regulating* high levels of negative emotion or distress (i.e., high levels of negative emotion may precede positive health behaviors; Thayer et al. 1994). Accordingly, these kinds of behaviors are often prescribed as part of psychiatric and medical treatments (Conn 2010; Jazaieri et al. 2012). In contrast, in healthy populations, theories typically suggest that greater positive emotions predict greater adaptive health behaviors in order to *maintain* or even increase levels of well-being (i.e., higher levels of positive emotion may precede positive health behaviors: Salovey et al. 2000). To the authors' knowledge, these two models, regulation versus maintenance, have never been directly compared. Thus, in this investigation, we sought to test which of these models,

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s11031-018-9729-8) contains Supplementary Material, which is available to authorized users.

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regulation versus maintenance, better explained the association between within-person fluctuations in emotion and future healthy behaviors in a sample of adults who were either psychologically healthy or diagnosed with common emotion-related disorders (e.g., major depressive disorder, social anxiety) during a 14-day experience sampling diary. We opted to test these models in these particular groups given the potential that adaptive health behaviors may have different emotional antecedents in emotionally-impaired versus emotionally-healthy individuals.

Adaptive behaviors and health

Unquestionably, the lion's share of recent research on positive health behaviors and psychological health has consisted of research investigating the psychological and physical benefits of exercise (c.f., Penedo and Dahn 2005; Reed and Ones 2006). From systematic trials of exercise interventions (e.g., Turner et al. 2016), to observational research through experience sampling (e.g., Dunton et al. 2014; Schöndube et al. 2016) and in-vivo assessment in laboratory (e.g., Mata et al. 2013), across a variety of samples (Maher et al. 2013; Huang et al. 2015; Ferrer et al. 2011; Mata et al. 2012). There is consistent evidence that exercise offers health benefits and may be considered a validated treatment for some affective disorders (e.g. Netz 2017). Benefits of exercise include increases in post-exercise positive emotions (Dunton et al. 2014; Gauvin et al. 2000; Mata et al. 2012; Schöndube et al. 2016) and reported well-being (Maher et al. 2013), with evidence suggesting that exercise decreases reports of depression symptoms (Conn 2010) and increases in negative emotion flexibility (Mata et al. 2013; Shields et al. 2015). Further, evidence from studies utilizing experience sampling, suggest that positive emotions may precede exercise (Kanning and Schoebi 2016; Niermann et al. 2016; Reichert et al. 2016; Schöndube et al. 2016) whereas negative emotions have been found to be unrelated to future physical activity (Liao et al. 2015).

Other behaviors have also been demonstrated to confer broad health benefits, including at the within-person-level. For example, there is considerable research demonstrating the role of social support in broader psychological adjustment and physical health (Holt-Lunstad and Smith 2012; Rini et al. 2014). Indeed, recent experience sampling research has directly tested the role of pro-social behaviors on emotional responses to daily stress demonstrating a real-time positive association between pro-social behaviors and increased positive as well as reduced negative emotion (Raposa et al. 2016). There is also a robust literature demonstrating the benefits of relaxation activities, including meditation. These benefits include decreases in within-person reported stress (e.g., Artemiadis et al. 2012), increases in reported well-being (e.g., Galante et al. 2016) and evidence of decreases in tonic and phasic levels of sympathetic nervous system activation (e.g., Jerath et al. 2015) and relative increases in parasympathetic activation, executive cognitive functioning, and immune system responses (e.g., Creswell et al. 2016). Lastly, there is evidence suggesting that hobbies or other enjoyable leisure activities confer clear health benefits. For example, engagement in hobbies has been shown to be psychologically protective in older adults (Hirosaki et al. 2009) and to confer mental health benefits in middle age (Takeda et al. 2015). Leisure time activities have also been shown to mitigate the daily effects of work-related stress (Sonnentag 2001). Importantly, these adaptive health behaviors may be related to each other. For example, there is evidence that physical activity is positively associated with study habits (Hashim et al. 2012) as well as nutrition and leisure activities (Mensink et al. 1997).

Emotion and adaptive health behaviors

Underlying dominant theories of emotion is the basic tenet that emotions evolved to facilitate adaptive responses to challenges in the environment (Ekman 1992; Frijda 1986; Panksepp 2011). Accordingly, most discrete emotions, including sadness, fear, anger, joy, and disgust, have associated action tendencies that have been well-established through laboratory research (sadness: Bonanno et al. 2008; fear: Öhman and Mineka 2001; anger: Carver and Harmon-Jones 2009; joy: Fredrickson 1998; disgust: Tybur et al. 2013). Moreover, emotions are largely understood to inform decision making with regard to future behaviors (Lowenstein and Lerner 2003). Indeed, specific theories predict *both* that the individual's current emotion-linked somatic experience (Bechara 2004; Naqvi et al. 2006) and/or their conscious conceptualization of an emotional experience (Barrett 2016; Schwarz and Clore 1996) can strongly influence future behavior. Moreover, an individual's anticipation of a future (emotional) experience can influence behavior (John and Gross 2004; Lowenstein and Lerner 2003). Accordingly, across the literature, there is a clear reference to adaptive health behaviors as operating in the service of *regulating affective discomfort* or distress (e.g., Thayer et al. 1994). From this perspective, an individual may feel discomfort or distress and then opt to engage in a behavior that they may anticipate will alleviate that discomfort. Indeed, exercise, relaxation, social and/or leisure activities/hobbies are often prescribed in common treatments for affective disorders characterized by high and persistent levels of distress (c.f., Galante et al. 2014; Stathopoulou et al. 2006).

Research on the regulation model has mostly demonstrated consistent associations between negative emotion and adaptive behaviors via trait-level or generalized reporting

(e.g., Thayer et al. 1994), and there is relatively little empirical evidence demonstrating a reliable time-based association between increased negative emotion followed by engagement in adaptive health behaviors (Kanning and Schoebi 2016; Liao et al. 2015; Reichert et al. 2016; Schöndube et al. 2016). However, a notable exception is recent evidence of a link between lower levels of positive emotion and more engagement in pleasant activities (e.g. sport, leisure, chatting) (Taquet et al. 2016). Specifically, this large-scale investigation by Taquet and colleagues (2016), utilizing ecological momentary assessment, found that when participants' current mood decreased, they were more likely to subsequently engage in activities to increase their mood (i.e. pleasant activities). Following such activities, participants reported an increase in mood. However, there is conflicting evidence suggesting that high levels of distress may disincentivize physical activity for many people (Catellier and Yang 2013; Stults-Kolehmainen and Sinha 2014). Such findings are representative of the complex relationship between emotion and behavior (see also, Gauvin et al. 2000; Mata et al. 2012).

Distinct from the above described regulation model, is theory and evidence that falls more closely in line with a model of *maintenance of positive emotional states*. In particular, there is considerable theoretical work suggesting that positive emotions beget positive health behaviors which then beget more positive emotions (Salovey et al. 2000; Seligman et al. 2005). For example, dominant models of positive emotion suggest that they evolved to facilitate and build critical resources, such as social relationships (Fredrickson 1998). In addition, unlike most negative emotions, positive emotions are largely associated with a behavioral orientation of approach (Burgdorf and Panksepp 2006; Updegraff et al. 2004), which might better facilitate actions in the service of long-term goals that may not always be physically comfortable in the moment (e.g., exercise/physical activity: Ekkekakis et al. 2011; Kanning and Schoebi 2016; Liao et al. 2015; Niermann et al. 2016; Reichert et al. 2016; Schöndube et al. 2016). Finally, there is some, albeit limited, evidence of a reciprocal relationship, over time, between positive emotions and adaptive behaviors such as social support seeking (Kok et al. 2013) that suggest an empirical foundation for this alternative perspective.

Although both these models indicate that engagement in adaptive health behaviors lead to increased positive affect (same outcome), the two models appear to explain two distinct processes (different paths). In general, it is clear that both negative and positive emotions might drive behavior in ways that map on to current models of activation and behavioral orientation. For example, most negative emotions are associated with withdrawal-related behaviors and positive emotions are generally associated with approach-related behaviors. Indeed, positive emotions seem to promote long-term well-being by increasing engagement in social interaction, physical activity, and learning-oriented activities (Fredrickson 1998). There is evidence to suggest that individuals tend to have a bias toward one behavioral orientation versus the other. Indeed, some individuals seem to be more likely to engage in behaviors driven by positive emotions (approach-related), and some seem to be more likely to engage in behaviors driven by negative emotions (withdrawal-related). This is based on considerable neuroimaging research suggesting biases in resting hemispheric activation (Davidson 1992, 1998). For example, this line of research has shown that individuals who report greater trait positive affect have increased activation in the left frontal region of the brain, whereas individuals who report greater trait negative affect have increased activation in the right frontal region of the brain (Tomarken et al. 1992). These results suggest dispositional tendencies for behavioral engagement that are related to either positive or negative emotional states. However, there is not sufficient evidence to say that despite having a bias, individuals couldn't use either framework, and that the use of one versus the other may be dependent on context. Indeed, engagement in adaptive health behaviors do require effort, hence a positive emotional precursor might increase the likelihood that they will engage in such behaviors, regardless of their particular tendency.

Objective

Given the clear role that adaptive behaviors such as exercise, relaxation, support seeking, and leisure activities play in health, there is a critical need to better understand ways in which current emotion may predict future behavior. Indeed, current therapeutic interventions are largely based on the regulation model thus, improvements to such interventions may be possible with increased understanding about the influence of emotion on health behaviors. Furthermore, most treatment research has focused on the role of negative emotion in psychopathology, however, increasingly it is evident that positive affectivity can be highly predictive of future psychological risk (e.g. Kendall et al. 2015), perhaps more so than negative affectivity. Accordingly, there is a need to better understand the way in which both negative and positive emotions influence behaviors that are clearly associated with psychological and physical health.

In the current investigation, we sought to explicitly test if within-person fluctuations in negative and positive emotion (i.e. reported changes in negative and positive emotion, over time) might predict engagement in future adaptive health behavior. The current sample consisted of adults that were either psychologically healthy or diagnosed with a common affective disorder clearly associated with emotion-related dysfunction and persistent distress (i.e., major depression

and/or social anxiety disorder). Given the possibility that the association between within-person emotion and future health behavior might differ depending on the emotional health of the individual, we explicitly included these two distinct groups of adults. The health behaviors (exercise, spent time with a supportive person, engaged in a hobby, and relaxation/meditation activities) included in the current investigation were selected due to the common prescription of these *specific* behaviors in current psychiatric and medical treatments (Conn 2010; Jazaieri et al. 2012; Linehan 2015; MacPhillamy and Lewinsohn 1982). Rather than focus on only one behavior at a time, we created an index composed of several health behaviors for our primary analysis. This was done with consideration for the likely variability in preferences for particular types of health behaviors. For example, less extroverted individuals may opt to seek support less (Luyckx et al. 2012).

Given the broadly discrepant theories of how emotions might influence these behaviors, we took an a-theoretical stance and sought only to carefully investigate these phenomena over the course of a 14-day experience sampling diary without stating any specific hypotheses or predictions. Experience sampling methodology is ideally suited for this purpose as it allows for *direct examination of associations from one moment in time to the next*, repeatedly, over the course of the sampling period. Moreover, following conventions of contemporary affective science (Bolger and Laurenceau 2013), this approach is optimal due to the ability to partial out within-person variance from between-person variance. This allows for investigation of changes that occur for each participant in the sample, over time, as well as investigation of differences between individuals in the sample. Although we made no explicit a-priori predictions, we did expect that evidence in support of a regulation model would be characterized by within-person increases in negative emotion *prior* to reports of adaptive health behaviors. We also expected that within-person increases in positive emotion *prior* to reports of health behaviors would be consistent with a maintenance model.

In our final analyses, we did consider a number of additional factors that might play an important role in how positive and negative emotions influence engagement in health behaviors. Specifically, we considered the potential role of enduring affect or mood on adaptive health behavior in the final model. Indeed, affective phenomena are thought to occur on multiple levels and more enduring affect or mood can influence momentary emotion and may broadly influence behavior (Russell 2003; Rosenberg 1998). We also considered the likelihood that adaptive behaviors at one moment in time likely predict future adaptive behaviors, given a long history of research suggesting that the best predictor of any future behavior is prior behavior (see applications in experience sampling: Bolger et al. 2003; Shrout and Lane 2012). Finally, we also considered the possibility that some health behaviors might be more likely to invoke certain emotional responses in some people. Indeed, such effects might influence the association between emotional responses and engagement in health behaviors. Accordingly, we built into our protocol measurement of not only emotions immediately preceding potential reports of behaviors but also emotions immediately following.

Design

Participants

Participants consisted of adults between the ages of 18–65 years, all part of a larger study aimed at investigating emotion processing in affective disorders. For the larger study, a total of 75 individuals who met criteria for a current DSM-IV diagnosis of major depressive disorder (MDD) and/or generalized social phobia (GSP) ($n=45$) (DSM-IV-TR; American Psychiatric Association 2000), or who were determined healthy controls (HC) ($n=30$), were recruited. A subsample of 60 individuals from the larger sample were identified for meeting inclusion criteria, and for completion of the experiential sampling diary. Inclusion criteria for the clinical (MDD/GSP) group was meeting the diagnostic threshold for a major depressive episode and/or social phobia, generalized subtype, (per the DSM-IV-TR). Inclusion criteria for the healthy group included a Global Assessment of Functioning (GAF; rated from the SCID-I) score greater than 79, absence of any Axis-I pathology (full or partially remitted) in the past 12 months, absence of any personality disorder (i.e., less than two symptoms endorsed on any SCID-II scale), no use of psychiatric medications in the past 12 months, and no evidence of elevated social desirability (i.e., scores greater than 25 on the Marlowe–Crowne Social Desirability Scale; Crowne and Marlowe 1960). Due to insufficient diary data[1], four of the 60 participants were excluded from the present study thus, the current sample consist of 56 total participants with 34 participants in the clinical group, and 22 participants in the control group.

Participants were recruited by fliers posted in the surrounding community of large Midwestern university in the

[1] Exclusion due to insufficient diary data was determined by following standard experience-sampling analysis procedures (Bolger et al. 2003). Specifically, participants with fewer than 13 completed diary entries, or who were two standard deviations below the mean of the original sample, were excluded from the present study. There were no significant demographic or diagnostic differences (two of the excluded participants were healthy controls, and two met criteria for generalized social phobia) between the final sample and the four excluded participants.

United States for a study on "Emotion in Daily Life". To assess for presence of affective disorders diagnostic interviews, (SCID-I; First et al. 2002, 1997; SCID-II) were conducted with all participants. Exclusion criteria for the clinical group included evidence of bipolar disorder (I or II), borderline personality disorder, current psychosis, and current use of medications in the following classes: benzodiazepines, beta-blockers, tricyclic antidepressants, antipsychotics[2]. Current use of other psychiatric medications (e.g. selective serotonin reuptake inhibitors), or currently being in therapy, were not causes for exclusion from the clinical group. In the clinical group, 61.8% reported currently (within the past month) receiving some form of psychotherapy, and 64.7% reported current use (within the past month) of psychiatric medications. There was considerable overlap between participants currently in therapy and those taking medication, indeed, there were only seven (20.6%) participants in the clinical group who reported only one form of current treatment and only ten (29.4%) participants in the clinical group who reported no treatment at all. Exclusion criteria for both the clinical (MDD/GSP) and the healthy group were the presence of visual impairment. Additionally, all participants needed to be 18–65 years of age and speak the English language fluently.

Main outcome measures

All individuals calling in response to the study fliers participated first in phone screening, conducted by trained research team members, to assess for potential eligibility for the larger study. Phone screens included adapted items from the Structured Clinical Interview to Diagnose Axis I disorders—DSM-IV-TR (SCID I; First et al. 2002) and the Interview Guide for Evaluating DSM-IV Psychiatric Disorders (Zimmerman 1994) to evaluate symptoms of MDD and GSP. Individuals who reported sufficient symptoms of MDD, GSP, or reported absence of any such symptoms, were invited to the laboratory for a thorough diagnostic evaluation.

Participants were compensated $25 for the in-person diagnostic interview, irrespective of study eligibility. Those individuals meeting eligibility criteria were placed into one of the two study groups and began study participation. Individuals first completed a questionnaire packet which included measures of depression, and basic demographics (i.e., gender, age, race, ethnicity, employment status). Given previous research showing that body mass index (BMI) is higher in individuals with depression and anxiety (Zhao et al. 2009), participants in the current sample were asked to report their current height and weight, in order to calculate BMI. Following completion of the questionnaires, participants returned to the laboratory for two separate study sessions consisting of a variety of cognitive-emotional tasks unrelated to this investigation and part of the larger project. However, during the first study session, all participants were trained by a research team member on how to complete the 14 day electronic diary, and then given a take-home manual.

Participants completed the diary portion of the study between the two laboratory sessions. Upon completion of the diary, participants returned to the laboratory to return the electronic diary, and complete the second (final) study session. Participants were compensated for the entire study with $75 and a $25 bonus (for completion of more than 90% of diary entries). Ethical approval of all parts of the current study was obtained by the Kent State University Institutional Review Board (IRB Number: 12-257) prior to the start of any data collection. Written informed consent was obtained from all participants prior to the diagnostic interview.

Diagnostic interview

A structured diagnostic interview was administered to all participants to determine study eligibility. Interviews were conducted by trained and reliable (reliability for symptom and diagnostic level was good $\kappa > .90$) doctoral students in clinical psychology, under the supervision of the last author, a licensed clinical psychologist. The interview consisted of an evaluation of current functioning, medical and psychiatric treatment history, as well as the SCID-1 (First et al. 1997), SCID II for DSM-IV Axis II Personality Disorders (SCID-II; First et al. 1997), and supplemental modules from the Anxiety Disorders Interview Schedule—Lifetime Version (i.e., the generalized anxiety disorder and social phobia modules: ADIS IV-L; DiNardo et al. 1994).

Depression

The Center for Epidemiological Studies scale (CES-D; Radloff 1977) was used to index depressive symptoms and current distress, and to verify diagnosis established in the diagnostic interview. The CES-D consists of 20-items and has been shown to demonstrate good validity and reliability in both general and clinical populations (Radloff 1977). In the current sample, internal consistency was high ($\alpha = .96$).

[2] Exclusion of these medication classes was related to aspects of the larger project unrelated to this investigation that involved the assessment of autonomic nervous system activity. All medications in those classes have been demonstrated to impact cardiovascular activity in ways that might interfere with specific hypotheses of the broader project.

Experience sampling diary

Adaptive health behaviors and positive and negative emotions were assessed using a 14-day computerized experience-sampling diary. Experience sampling data were collected using a programmable Palm Centro personal desk assistant (PDA), programmed with the Purdue Momentary Assessment Tool (PMAT; http://www.cfs.purdue.edu/mfri/pages/PMAT/Index.html) (Weiss et al. 2004). During the 14-day diary period, participants were prompted to answer a series of forced-response questions at random times, five times per day, over a 14 h period chosen by the participant (e.g. 9 am–11 pm). Participants were able to complete a total of 70 diary entries during the 14-day period. As needed, participants were able to delay or stop a diary prompt if they were otherwise occupied (e.g., when driving a car). Diary prompts never were closer than 2 h together in time and never greater than 5 h apart, within the 14 h daily sampling period.

Current self-reported emotion

At the beginning of each diary prompt (occurring five times per day), participants were asked to rate their current emotional state on a 5-point Likert scale (1 = not at all, 5 = extremely). Specifically, participants rated the extent to which they currently felt six negative emotion words (fear, sadness, distress, disgust, anger, guilt) and six positive emotion words (enjoyment, happiness, amusement, affection, satisfaction, relief) to comprise two scales, one for current negative affect (*PCNA*) and one for current positive affect (*PCPA*). These scores were included in the final analytic model (described below) to indicate level of current emotional state, for each participant, for each diary signal. Following the procedure outlined by Cranford and colleagues (2006; see also Shrout and Lane 2012) the scales' between-person reliability (R_{kf}; estimating measurement precision regarding systematic between-person differences across days) and within-person reliability (R_c; estimating measurement precision regarding systematic change of persons from day to day) were computed; reliability of both the negative affect scale ($R_{KF} = .99$; $R_C = .77$), and the positive affect scale ($R_{KF} = .99$; $R_C = .82$), were found to be good.

Reported health behaviors

At each diary prompt, participants reported on a three-point scale, either: "yes"; "no"; or "no but I thought about it a lot"; in response to prompts of specific actions that they engaged in since the last diary signal. Actions included the following adaptive health behaviors: (1) exercise; (2) spent time with a supportive person; (3) engaged in a hobby; and (4) relaxation/meditation activities. At each diary signal, participants were always prompted for all four behaviors. Additionally, a short description of each behavior was provided at each diary prompt, as well as in the hardcopy diary manual, in order to ensure consistent reporting across participants. These data were examined in several ways. For the primary analysis, a summary score of endorsed behaviors (only a "yes" indicated endorsement) was used as both the dependent variable (summed behaviors in the next signal: *NextPB*) as well as a predictor (summed behaviors in the current signal). In addition, in order to explore any differences in the frequency of behaviors both within and between groups, a score was created to represent each participant's proportion of positive health behaviors across all diary signals. Specifically, we created this score by taking the total number of reported positive health behaviors (across the diary) for each participant and dividing it by the total number of diary signals that the individual responded to (e.g. 35 reported positive health behaviors divided by 53 total diary signals = 0.66). Scores were created for all behaviors summed, and also for each of the four types of behaviors.

Emotion response following health behaviors

If participants endorsed any of the four adaptive health behaviors, they were always and immediately asked to indicate their emotional response *after* the behavior by answering the question, "How did you feel after this action". Participants answered by selecting an emotion from a list of emotion terms, including: relief, guilty, distress, calm, satisfied, lonely, numb, content, angry, happy, shame, accepted, disgust, tense, grounded, fearful. Participants typically endorsed only one emotion from the list. A score was created for each participant, for each behavior, to indicate the proportion of positive emotion reports relative to all (positive and negative) emotion reports. For example, across the full diary, a participant may have endorsed "exercise" five times. Following three of these exercise reports, the participant might have then rated their emotion as "happy", and following two of the exercise reports, the participant might have then rated their emotion as "angry". In this scenario, the score would be the proportion of of positive emotion reports (= 3) to all reports (= 5), which in this case would equal 60% (or 3/5).

Data analytic strategy

This study aims to test which of the proposed models (regulation versus maintenance) better explains the association between within-person changes in emotion and future healthy behaviors, in a sample of adults diagnosed with affective disorders and HC. Given the multilevel structure of these data (signals nested within individuals), a multilevel regression model was deemed most appropriate and in-line

with analytic approaches used in contemporary affective science (Bolger and Laurenceau 2013). Specifically, this approach was used to predict engagement in future positive health behaviors (*NextPB*, a continuous score to indicate behaviors in the next signal) from between-person and within-person variability in affect reported during the previous diary signal. Both current negative (*PCNA*) and positive (*PCPA*) affect were entered together in the analysis to provide a more rigorous test (given their shared variance), and both negative and positive affect were person-centered at Level 1 of the model, in order to reduce differences due to reporting and group status. Lastly, the *sum* of positive health behaviors reported on the current signal (*CurrentPB*) was also included in the model. The intercept and slope were considered to be random, and an autoregressive structure was imposed on the level-1 error covariance matrix.

Equation for the signal-level within-person (level 1)

$$\text{NextPB}_{ij} = \beta_{0j} + \beta_{1j}\text{PCNA} + \beta_{2j}\text{PCPA} + \beta_{3j}\text{CurrentPB} + r_{ij}$$

In the above (level 1) equation, NextPB is the predicted outcome for a person (*i*) on signal (*j*), β_{0j} is the regression intercept for this person, β_{1j} is the regression slope for the effect of person-centered negative affect on positive health behavior for this person, β_{2j} is the regression slope for the effect of person-centered positive affect on positive health behavior for this person, β_{3j} is the regression slope for the sum of positive health behaviors for this person on the current signal, and r_{ij} is the residual component for this person.

In the level 2 equation, specified below, the between-person effects of affect and group membership were accounted for. Thus, average positive and negative affect and indication of group membership were included at this step of the model.

Equations for the person-level between-person (level 2)

$$\beta_{0j} = \gamma_{00} + \gamma_{01}\text{Group} + \gamma_{02}\text{MeanNA} + \gamma_{03}\text{MeanPA} + u_{ij}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

In the Level 2 equation, the intercept (β_{0j}) of person (*i*) is predicted by the average outcome (γ_{00}) (fixed effects), group membership (γ_{01}), average negative affect (γ_{02}), average positive affect (γ_{03}), and by the persons' random effects (u_{ij}) (deviation from the fixed effects). Due to the potential of day-level effects that were not captured in the final two-level model, these data were also analyzed in a three-level model where day-level effects could be examined. No significant effect of day emerged in this sample ($F = 1.26$, $p = .2$), and the inclusion of day-level effects did not change the reported results from the final model.

Results

Descriptive statistics

Examination of key study variables indicated that the clinical and healthy groups did not significantly differ on any demographic characteristics (see Table 1). On the CES-D, in the current sample, the mean and standard deviation for the clinical group (M = 28.09, SD = 12.04) was comparable to other clinical populations (M = 24.42, SD = 13.51; Radloff 1977), and the healthy group in this sample (M = 3.14, SD = 2.73) was comparable to other general populations (M = 9.25, SD = 8.58; Radloff 1977). BMI for the current sample (calculated from self-reported height and weight) was found to be significantly higher in individuals in the clinical group (M = 30.20, SD = 8.75), as compared to the healthy control group (M = 23.49, SD = 4.24) $t(51) = -3.70$, $p < .01$. For sample diagnostic information, see Table S1 provided in the Supplemental Materials. Moreover, diary compliance (i.e. percentage of completed diary entries) was high for both the clinical group (87.18%) and the healthy control group (77.66%), and there was no difference in diary compliance between the two groups $t(54) = 1.6$, $p = .12$. In the full sample, the range of the number of completed diary entries was 17–70 (M = 59.46, SD = 14.64). Frequency of reported positive health behaviors, controlling for variation in number of responded signals, or the proportion of behaviors reported were also examined for group differences across the diary, and no significant differences emerged in how much the groups engaged in positive health behaviors $t(54) = -1.29$, $p = .20$ (see Table S2 in the Supplemental Materials). A trend towards significance did, however, emerge between the groups on engagement in a hobby ($p = .07$) such that individuals in the clinical group reported less engagement in a hobby across the diary, as compared to the healthy group. Reported engagement in exercise, relaxation/meditation, and spending time with a supportive person, were generally correlated with each other in a positive direction in the full sample. Reported engagement in a hobby was, however, only correlated with relaxation/meditation, but not with the other positive health behaviors (see Table S3 in the Supplemental Materials). Mean positive and negative affect across the entire diary period were also examined for group differences. As expected, significant differences emerged between the groups on these variables. Specifically, the clinical group reported more negative affect (M = 1.61, SD = 0.47) as compared to the healthy group (M = 1.11, SD = 0.09), $t(54) = -36.30$, $p < .01$, and less positive affect (M = 2.10, SD = 0.56) as compared to the healthy group

Table 1 Characteristics of study participants ($N = 56$)

Characteristic	Clinical group ($n = 34$)	Healthy controls ($n = 22$)	Chi square/t test
Age	M = 36.26, SD = 13.76 range: 19–62 years	M = 30.05, SD = 12.77 range: 18–63 years	$t(54) = 1.7$, $p = .10$
BMI	M = 30.20, SD = 8.75 range: 19.66–56.64	M = 23.49, SD = 4.24 range: 18.65–35.73	$t(51) = -3.70$, $p < .01$
Frequency			
Sex			
Female	25 (73.5%)	18 (81.8%)	$\chi^2(1) = .52$, $p = .47$
Male	9 (26.5%)	4 (18.2%)	
Race			
Asian	2 (5.9%)	0	$\chi^2(2) = 1.79$, $p = .41$
African American	3 (8.8%)	1 (4.5%)	
White	29 (85.3%)	21 (95.5%)	
Ethnicity			
Hispanic	0	0	
Non-hispanic	34 (100%)	22 (100%)	
Current employment			
Full-time	7 (20.6%)	6 (27.3%)	$\chi^2(1) = .34$, $p = .56$
Part-time	11 (32.4%)	8 (36.4%)	$\chi^2(1) = .10$, $p = .76$
Attending school	8 (23.5%)	9 (40.9%)	$\chi^2(1) = 1.91$, $p = .17$
Current education level			
Partial college, or still in college	15 (44.1%)	8 (36.4%)	$\chi^2(5) = 3.61$, $p = .61$
Graduated 2 year college	5 (14.7%)	1 (4.5%)	
Graduated 4 year college	7 (20.6%)	6 (27.3%)	
Completed graduate school	3 (8.8%)	3 (13.6%)	

(M = 2.64, SD = 0.55), $t(54) = 26.35$, $p < .01$, across the diary period. Lastly, examination of proportions of positive affect following each positive health action showed no significant differences across the groups (see Table S4 in the Supplemental Materials), and there were no differences in the proportion of positive affective responses reported following each behavior across the sample and within group. This was tested by use of a repeated measures ANOVA, where the proportion of positive affect following each positive health behavior was included as the within-subject variable, and group membership was included as the between-subject variable. No significant effect of group membership on level of positive affect following any of the positive health behaviors emerged in this sample, $F(3,38) = 1.74$, $p = .20$. Additionally, no significant within-subject effects emerged to suggest presence of differences in level of positive affect depending on the positive health behavior $F(3,38) = .80$, $p = .49$. In short, for all participants, all behaviors elicited primarily positive affect.

Primary data analysis

Results (solution for standardized fixed effects can be found in Table 2) of the model specified above indicated that levels of person-centered positive affect in the prior signal significantly predicted positive health behaviors during the next signal ($B = 0.09$, SE = .04, $p = .01$). As expected, prior positive behaviors also predicted behaviors reported in the next signal ($B = 0.13$, SE = 0.03, $p < .001$). Additionally, mean positive affect (positive affect averaged across the full diary, reflecting more enduring affective phenomena such as mood) significantly predicted engagement in positive health

Table 2 Fixed effects estimates for predictors of positive health behaviors: using standardized raw scores (see Baldwin et al. 2014), β is an estimate of effect size

Effects	β	*SE*	*t*	*p*
Intercept	−0.04	0.11	−0.40	0.69
Current person-centered negative affect	−0.01	0.03	−0.20	0.84
Current person-centered positive affect	0.09	0.04	2.46	0.01
Average negative affect	−0.14	0.10	−1.39	0.17
Average positive affect	0.25	0.09	2.74	0.01
Group membership*	0.12	0.14	0.86	0.39
Current positive health behaviors	0.13	0.03	4.93	< 0.0001

*Healthy controls or clinical group (MDD and/or GSP)

behaviors ($B = 0.25$, SE = .09, $p = .01$). Standardized estimates of the fixed effects were utilized as an approximation of effect size (see Baldwin et al. 2014 for more information about this solution). Using this approach, small to moderate effect sizes were obtained. Notably, the issue of effect sizes in the context of multi-level modeling is a complicated one, and currently there is no consensus regarding the optimal way to compute effect sizes. Results utilizing the unstandardized scores can be found in Table S5 provided in the Supplemental Materials. Together, these results supported a maintenance model, such that *both* within-person increases in positive affect and enduring levels of positive affect predicted future report of positive health behaviors, irrespective of group status. There were no significant effects for within-person variation of negative emotion or enduring negative emotion and no main effect for group. Moreover, all possible interaction effects (e.g., group membership x person-centered positive and negative affect, and group membership x positive health behavior) were considered, however, no significant effects were found. Thus, these interaction effects were excluded from the final model. Lastly, given the potential importance of factors such as age, gender, BMI, and current psychological treatment (psychotherapy and/or psychiatric medication) on emotion as well as health behaviors, a follow-up analysis was conducted to examine these factors as covariates in the final model. No significant effects of age, gender, BMI, or current involvement in treatment (current psychotherapy or current psychiatric medication) emerged in this sample. Additionally, the reported results of the final model did not change after the inclusion of these covariates.

Conclusion

This investigation aimed to test the role of antecedent fluctuations in negative and positive emotion and future adaptive health behavior in a sample of adults that were either psychologically healthy or diagnosed with a common emotion-related disorder (i.e. major depression and/or social anxiety disorder), by use of a 14-day experience sampling diary. Consistent with a maintenance model of current positive emotion states (Salovey et al. 2000), within-person deviations in positive affect, specifically, increases in positive affect, emerged as a significant predictor of future health behaviors such as exercise, relaxation, social support-seeking, and hobbies, in the present sample. Indeed, the maintenance model of positive emotional states suggests that positive emotions facilitate behaviors that are related to physical and psychological well-being, but that might not be comfortable in the moment (e.g., exercise: Ekkekakis et al. 2011). As such, these results align with previous research (Burgdorf and Panksepp 2006; Updegraff et al. 2004) and suggest an association between positive emotions and behavioral approach towards activities which might facilitate long-term goals. Unlike negative emotional states, which are associated with withdrawal related behaviors potentially serving short-term functions, positive emotions might increase motivation for activities that build enduring physical, psychological, and social, resources (e.g. exercise, interaction with other people). Moreover, enduring or mean-levels of positive affect and prior engagement in adaptive health behaviors, also predicted future adaptive behaviors. In contrast, negative emotion did not appear to influence adaptive behaviors in this sample, neither within-person deviations in negative affect nor enduring (mean levels) negative affect, highlighting the unique role of positive emotion in health behaviors and supporting a maintenance model. These findings are consistent with dominant theories of positive emotions, suggesting that positive emotions help to build critical resources and facilitate an approach-related behavioral orientation (Fredrickson 1998; Updegraff et al. 2004). Most important, these findings also align with a limited body of prior research showing a clear reciprocal relationship between positive emotions and adaptive behaviors (e.g. social support seeking) that builds over time (Kok et al. 2013), as well as with a growing body of research showing that positive emotions precede engagement in physical activity (Kanning and Schoebi 2016; Liao et al. 2015; Niermann et al. 2016; Reichert et al. 2016; Schöndube et al. 2016). Consistent with prior literature (Mata et al. 2012), albeit perhaps inconsistent with conventional wisdom, no evidence of group differences in behaviors nor deviations in affect emerged in this investigation, suggesting that a maintenance model may be appropriately applied to both healthy individuals, as well as those suffering from emotion-related disorders, despite clear differences in the mean intensity of affect across the sampling period. Indeed, our findings speak most to how momentary fluctuations around one's own mean can influence the behaviors that follow. It should be noted that although these findings align with the above stated models, results from a single study cannot alone confirm dominant theories of emotion. Thus, these data should be interpreted with some caution.

Interestingly, these findings suggested similarity between the clinical and healthy groups in both the frequency of adaptive health behaviors reported across the diary, and the positive affect reported following such actions. Specifically, both groups in this sample reported engagement in a variety of adaptive behaviors, and both groups also reported feeling better (more positive affect) following these behaviors. This pattern of results is consistent with prior research showing that even individuals with severe mental illness experience increased positive mood following many of these adaptive behaviors (e.g. Mata et al. 2013; Yanos and Rosario 2014). Indeed, this finding is largely why such behaviors are commonly prescribed in psychological treatments. Notably, however, our findings relating to frequency of behaviors are

inconsistent with some literature, including a recent meta-analysis suggesting that individuals with major depressive disorder engage in physical activities less frequently than healthy adults (Schuch et al. 2017). Indeed, we were surprised at our own results.

Notably, these findings were also inconsistent with prior evidence presented by Taquet et al. (2016), showing that lower levels of positive emotion predict more engagement in pleasant activities which in turn predicts increased positive mood. However, this discrepancy may be due to key methodological and statistical differences between the two studies. First, in our research, we examined negative and positive affect as independent dimensions (rather than on a continuum from negative to positive, as seen in Taquet et al. 2016), an approach that has been strongly supported by contemporary affect science and allows for examination of complex patterns of co-occurring positive and negative affect (Larsen et al. 2001, 2017). Moreover, we partialed out the between-subjects component of affect (i.e., person means) from within-person variability or within-person-level variation in affect (i.e., person-centered deviations) an increasingly common convention in intensive longitudinal designs (Bolger and Laurenceau 2013). As such, we were able to test the influence of all parts of affect variability in one model and therefore our analysis is not only quite different, but also more likely to identify different components of affect as relevant to our research question (in this case, it was within-subject deviations in positive affect). Perhaps more important, is that we used a hierarchical framework in our analysis in order to appropriately estimate the nested nature of these data, between and within persons, from one diary signal to the next. The benefit of this approach is not only more sensitivity in measurement but also more effective characterization of error in the model and in particular, the modelling of the degree to which auto-correlation is present.

Clinical implications

Given the large and robust body of research providing clear evidence of health benefits afforded by engagement in adaptive health behaviors such as these, our findings may have important clinical implications. Currently, exercise, relaxation, social and/or leisure activities/hobbies are commonly prescribed in psychological treatments for affective disorders characterized by high and persistent levels of distress as well as in treatments for medically ill patients, experiencing significant environmental stress. This approach has often been theoretically justified by a regulation model. Across many studies, including ours, the consequence of these behaviors is typically higher reported positive affect. However, the present findings suggest that interventions might perhaps benefit from an initial focus on increasing positive affect, prior to prescribing these behaviors and related activity. Indeed, our data clearly suggest that it is positive affect that is antecedent to adaptive health behaviors, not negative affect (or distress). Accordingly, interventions that include these behaviors may benefit from a slower approach, allowing a momentum of positive affect to build in order to facilitate engagement in adaptive behaviors that may be more effective over time. In fact, there is a limited body of literature showing that positive mood inductions (presentation of happy faces or presentation of funny cartoons, happy music) can be effective in increasing positive mood in patients with affective disorders (Falkenberg et al. 2012). Our findings suggest that clients might benefit from some form of positive mood induction prior to more extensive behavioral activation. Although behavioral activation is most often administered with the goal to increase positive affect in clients, engagement behaviors often suggested in such interventions (e.g. spend time with a friend, exercise) do require significant effort. Therefore, engagement in positive mood induction (e.g. listen to music) prior to behavioral activation might be a preferable approach as engagement in positive mood induction is likely less demanding, as compared to behavioral activation, during the beginning stages of therapy. Further, positive mood induction might increase client motivation for behavioral activation, in a more spontaneous or natural manner, potentially decreasing time spent on building motivation by the therapist. Certainly, more research on the specific associations between within-person fluctuation in emotion and adaptive behaviors is needed.

In addition, by indexing multiple behaviors simultaneously in this investigation we were also able to examine their association to each other. Although correlations among behaviors were modest, all behaviors, minus leisure activities which was only correlated with relaxation, were consistently positively related to each other. Indeed, we also found, as expected, that behaviors enacted at a given time predicted future behavior. Accordingly, it is possible that prescriptions for adaptive behaviors that are more diverse and inclusive of multiple behaviors may be more effective in precipitating future behaviors. Finally, our finding that leisure activities/hobbies were not associated with most of the other behaviors (except for relaxation) is interesting and is discrepant from prior studies (e.g. Mensink et al. 1997). Accordingly, future research should more explicitly test how these behaviors are associated with each other so as to better understand their broad impact on health and most efficiently harness them in interventions.

Limitations

There were some notable limitations to this study. *First*, the sample size was moderate. Indeed, given the time-consuming and costly nature of experience sampling diaries, sample sizes, particularly in studies involving clinical populations

are often limited. However, experience sampling methodology is ideal for examination of within-person fluctuations in emotion, thus, preferable. Moreover, the nature of experience sampling methodology (i.e. frequent and random assessment over an extended period of time) allows for highly sensitive measurement and analytical strategies that can more efficiently test complex, nested relationships (Bolger et al. 2003; Bolger and Laurenceau 2013). Indeed, the demand for larger sample sizes to achieve reliable findings can be less because the frequency of measurement, hence sensitivity, is considerable. Given the moderate sample size in the current study, it will be important to replicate the present study in a larger sample where such differences can be explicitly tested.

Second, participants in this sample were asked to self-report their engagement in health behaviors without providing much detail on the activity. Accordingly, there might be variation in reporting of such actions (e.g. some might report engaging in exercise that lasted for only a few minutes, whereas another individual might only report engaging in exercise when the activity lasted for over 60 min). However, our findings were still quite unambiguous and there is prior research suggesting that affective benefits gained from variable intensity activities may be equivalent (e.g. exercise: Ekkekakis et al. 2011). Additionally, because participants were able to delay (if needed) providing their self-report of emotional responses that followed the health behavior, these reports might be confounded and subject to recall bias. *Third*, we could not measure every possible adaptive behavior. In particular, we did not include some key behaviors that also exert influences on psychological and physical health. For example, sleep was not included in the present study. This would certainly be important to examine in future research. *Lastly*, the current study may have been limited by the frequency of diary prompts. Indeed, emotions fluctuate at a rapid pace and in order to accurately capture emotion responses, more frequent diary prompts might be necessary. Notably, however, we did adhere to common conventions in experience sampling studies of emotion. Unfortunately, increasing the frequency of prompts also increases the burden on participants, and often coincides with a shortened period of sampling (Connor and Lehman 2012).

Although the goal of this study was to test two specific models that aim to explain the influence of antecedent emotional states on future health behaviors, it is important to consider the possibility of alternative explanations of the findings from the present study. For example, it is possible that simply making the decision to engage in a health behavior could increase positive emotion that is then reported as antecedent to the activity itself. Further, it is also possible that a third variable (e.g. increased access to health promoting activities) could influence both the increase in positive emotion and engagement in health behaviors. Thus, it will be important for future research to investigate the relationship between emotion and health behavior in greater detail, perhaps by utilizing more frequent diary prompts and expanding the sample size. Additionally, future studies may further explore the possibility of a bidirectional feedback model using dynamic models of individual change (e.g., Falkenström et al. 2017) or time-series panel analyses (e.g., Ramseyer et al. 2014). Lastly, as the current study relied on a daily diary approach, it is also important to consider measurement reactivity (Kazdin 1974). Indeed, the act of participating in the current study, where participants were asked to report on their behaviors several times per day, might have had some therapeutic effect by itself. For example, daily diary prompts might have served as reminders for participants to engage in adaptive behaviors, similar to intervention studies utilizing mobile phone applications (e.g. Nelson and Hayes 1981; Painter et al. 2017). Thus, how these findings might generalize to a population that is not engaging in daily tracking of behaviors and mood, remains unclear.

Conclusion

This investigation aimed to test competing models (maintenance versus regulation) of the influence of antecedent emotional states on future health behaviors, by use of experience sampling methodology. Findings from this study are consistent with a maintenance model, and suggest that *within-person increases in positive affect* not negative affect, *precedes adaptive health behaviors*. In the current sample, these findings apply to both healthy individuals and individuals diagnosed with common emotion-linked psychological disorders. Thus, these novel findings might have potential clinical implications as many treatments, across a broad range of medical and psychological illnesses, prescribe engagement in health behaviors for the purpose of increasing positive mood and reducing distress. Certainly, these data suggest that future studies should continue to test and verify these associations so that when these prescriptions are made, they can be most effectively enacted.

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