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ORIGINAL PAPER

Temporal Changes in Mindfulness Skills and Positive and Negative Affect and Their Interrelationships During Mindfulness-Based Cognitive Therapy for Cancer Patients

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Abstract

Objectives While efficacy research on mindfulness-based interventions in cancer patients is available, research on possible mechanisms of change is lacking. The current study investigated general and week-to-week changes and interrelations in mindfulness and positive and negative affect in Mindfulness-Based Cognitive Therapy (MBCT) for cancer patients.

Methods In total, 163 cancer patients completed face-to-face or online MBCT. Mindfulness and positive and negative affect were measured weekly during the intervention. Autoregressive latent trajectory models were used to evaluate general and week-to-week effects.

Results Overall, mindfulness and positive affect increased, and negative affect decreased during MBCT. Higher general levels of mindfulness were associated with higher general levels of positive affect. Regarding week-to-week effects, positive affect in weeks 3, 7, and 8 predicted an increase in mindfulness in the following week. Various general relations were observed between mindfulness and negative affect, showing that higher mindfulness was related to less negative affect. To the contrary, week-to-week effects showed higher mindfulness consistently predicted increased negative affect in the subsequent week.

Conclusions In cancer patients, mindfulness appeared to be more robustly related to negative than to positive affect. Furthermore, mindfulness in one week was related to an increase of negative affect in the following week, possibly due to turning towards previously suppressed negative emotions. However, when focusing on the whole course from start to end, the increase of mindfulness was related to a decrease of negative affect, possibly due to acceptance of and exposure to negative emotions. Our findings reveal the complexity of mechanisms of MBCT and illustrate the necessity of sophisticated models with longitudinal measurements to truly elucidate these mechanisms.

Trial Registration Clinical Trials.gov: NCT02138513.

Keywords Mindfulness · Affect · Working mechanism · Cancer · Autoregressive latent trajectory models

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Thirty to 50% of cancer patients and survivors struggle with significant psychological distress and related negative emotions (Carlson et al., 2004; Mehnert et al., 2018). Mindfulness-based interventions (MBIs) are increasingly used in cancer patients to alleviate psychological distress. Mindfulness entails paying attention to the present moment, on purpose and with a nonjudgmental attitude (Kabat-Zinn, 1994). Mindfulness includes observing and describing experiences, acting with awareness, and nonjudging of and nonreactivity to inner experience (Baer et al., 2008; Brown & Ryan, 2003). Mindfulness skills can be trained. As a consequence of mindfulness practice, state mindfulness can increase. In turn, increased state mindfulness can eventually lead to an increase in trait mindfulness (Kiken et al., 2015).

A recent meta-analysis with more than 3000 cancer patients in 29 independent randomized controlled trials reported reductions in psychological distress, anxiety, and depression at post-treatment and follow-up (Cillessen et al., 2019), which is similar to other, smaller meta-analyses (Haller et al., 2017; Zhang et al., 2015). Although a substantial number of cancer patients derive benefit from MBIs, there is still room for improvement (Cillessen et al., 2019). In an RCT on MBCT and internet-based Mindfulness-Based Cognitive Therapy (eMBCT) for cancer patients, 60% of individual pre- to post-treatment difference scores did not statistically significantly change (Compen et al., 2018). To increase therapeutic gain and reduce non-response to MBIs, a focus on working mechanisms is necessary (Kazdin, 2007). However, research on working mechanisms of mindfulness is limited compared to research on effectiveness, especially in cancer patients. Furthermore, previous research often relied on simple mediation models that assessed the mediator only once, limiting the ability to evaluate differential relations of mechanisms over time and to determine direction of effects (Kazdin, 2007).

Despite its limitations, previous research on working mechanisms has provided relevant insights. One of the most studied working mechanisms of MBIs is mindfulness. A meta-analysis of all available mediation studies in a broad clinical and non-clinical population showed that MBIs result in increases in mindfulness that affect intervention outcomes in a positive manner (Gu et al., 2015). This finding was replicated in another meta-analysis that focused on mechanisms of MBIs for recurrent major depressive disorder (van der Velden et al., 2015). Improvements in emotion regulation are another mechanism that is increasingly studied. Gu et al. (2015) found strong and consistent evidence for emotional reactivity as a working mechanism. The mindfulness-to-meaning theory explains how increases in mindfulness and emotions may result in more beneficial outcomes (Garland, Farb, et al., 2015; Garland, Geschwind, et al., 2015). Mindfulness enables decentering and broadened awareness, creating space for positive affect, resulting in an upward spiral of positive emotions. Therefore, negative habitual patterns, including negative affect, can extinguish.

Different types of research have revealed evidence for a relation between mindfulness and positive affect. Cross-sectional research showed mindfulness relates to positive affect (Jimenez et al., 2010; Malinowski & Lim, 2015). However, a meta-analysis of MBIs did not reveal consistent effects of MBIs on positive affect (Goyal et al., 2014). Randomized controlled trials (RCTs) of MBIs using experience sampling showed gradual increases of positive affect over time in depressed patients (Garland, Farb, et al., 2015; Garland, Geschwind, et al., 2015; Geschwind et al., 2011). However, a study of mindfulness and positive affect assessed on a daily basis during an MBI for the general population only found partial evidence for a temporal sequence (Snippe et al., 2015). The authors found that mindfulness predicted changes in positive affect, but positive affect did not predict subsequent changes in mindfulness (Snippe et al., 2015).

MBIs are known to reduce negative affect (Sedlmeier et al., 2012) and symptoms of psychiatric disorders as depression, which often go hand-in-hand with negative affect (Goldberg et al., 2017). One study tested the temporal relations between mindfulness and negative affect (Snippe et al., 2015). This study measured mindfulness and negative affect daily during an MBI for the general population. The authors found that mindfulness predicted decreases in negative affect, but negative affect did not predict subsequent increases in mindfulness (Snippe et al., 2015).

The current study tested general and week-to-week associations between mindfulness and positive and negative affect in a group of cancer patients and survivors during their participation in MBCT or eMBCT. To investigate both general and week-to-week patterns over the course of MCBT simultaneously, we utilized autoregressive latent trajectory (ALT) models (Bollen & Curran, 2004). These models overcome some issues of the simple meditation models, because multiple measurements of potential mechanisms can be included, and the relation between different working mechanisms can be studied (Kazdin, 2007). Separate models were created for mindfulness and positive affect, and mindfulness and negative affect. For both models, we expected that intercepts (general levels) and slopes (general changes over MBCT) would be related; for mindfulness and positive affect, we expected positive relations; for mindfulness and negative affect, we expected negative relations. Based on the mindfulness-to-meaning theory (Garland, Farb, et al., 2015; Garland, Geschwind, et al., 2015), we expected positive week-to-week relations between mindfulness in a certain week and positive affect in the subsequent week, and vice versa. For mindfulness and negative affect, we expected negative week-to-week relationships from mindfulness in a certain week, to negative affect in the subsequent week.

Methods

Participants

Participants were recruited through various online (for example, Facebook) and offline (for example, newspapers) media outlets. Interested participants could self-enroll on the study website, and inclusion criteria were verified via telephone. Inclusion criteria were as follows: (1) having a diagnosis of any type of cancer; (2) experiencing at least mild psychological distress (a score of ≥ 11 on the Hospital Anxiety and Depression Scale (HADS); Spinhoven et al., 1997; Zigmond & Snaith, 1983); (3) computer literacy and

internet access; (4) good command of the Dutch language; and (5) willingness to participate in either the face-to-face or internet-based mindfulness intervention. Exclusion criteria were the following: (1) severe psychiatric morbidity such as classifications with a high risk for psychosis like bipolar disorder, schizophrenia spectrum, and other psychotic disorders and a high risk for current suicidality (suicide-related behaviors with suicidal intent). Potential participants were directly asked whether severe psychiatric morbidity was present in the telephone screening. In the baseline assessment, the Structural Diagnostic Interview for DSM-IV (SCID-IV; First et al., 1997; Spitzer et al., 1992) was used to verify the (1) absence of severe psychiatric morbidity (more on the use of the SCID-IV below); (2) change in psychotropic medication within 3 months of baseline; and (3) current or previous participation in MBCT or MBSR. Patients provided written informed consent prior to participation. More details about the recruitment procedure can be found elsewhere (Compen et al., 2015).

In total, 245 patients were included in the BeMind project. The current study included only patients ($n = 163$; 67%) who completed at least four sessions of MBCT ($n = 84$) or eMBCT ($n = 79$) (Kuyken et al., 2008; Teasdale et al., 2000). Descriptive statistics on these groups can be found in Table 1. There were no statistically significant differences in gender, age, education level, type of cancer, time since diagnosis, psychiatric diagnosis (depression/anxiety), baseline distress or mindfulness, and positive and negative affect between participants who completed at least four sessions vs. participants that dropped out of the intervention, and between participants randomized to MBCT vs. eMBCT. Intervention completion did not significantly differ between MBCT (70%) and eMBCT (63%). Participants in eMBCT completed significantly more sessions (M = 8.5; SD = 1.4) than those in in the MBCT condition (M = 7.8; SD = 1.3).

Of the included 163 patients, 85% ($n = 138$) were female, and the mean age was 52 years (SD = 10 years). Most participants were highly educated ($n = 115$; 71%). The majority had breast cancer ($n = 103$; 63%). Most patients were treated with curative intent (self-reported); that is, their treatment focused on full recovery, rather than palliation ($n = 142$; 87%). On average, participants received a cancer diagnosis more than 3 years ago (M = 3.4 years, SD = 4.7 years). Patients were moderately distressed when entering this study (score on Hospital Anxiety and Depression Scale (Spinhoven et al., 1997; Zigmond & Snaith, 1983); M = 17.8, SD = 6.9).

Presence of a depression or anxiety disorder was established with the relevant modules of the SCID-IV (First et al., 1997; Spitzer et al., 1992). Anxiety disorders included panic disorder, agoraphobia, social anxiety disorder, specific phobia, and generalized anxiety disorder. The SCID-IV was administered by a trained interviewer who completed a Master in Behavioral Science degree (F.C.), supervised by either an experienced psychiatrist (E.B. or A.S.) or psychologist (M.v.d.L.). All interviews were audiotaped. Based on the SCID-IV, 31 patients (19%) suffered from depression, and 16 patients (10%) had an anxiety disorder (generalized anxiety disorder: $n = 6$; specific phobia: $n = 3$; panic disorder: $n = 1$; social phobia: $n = 1$; other: $n = 5$). For more details, see Compen et al. (2018).

Procedures

The current study reports secondary analyses of data from the BeMind project, a multicenter, three-armed randomized controlled trial in distressed cancer patients comparing group face-to-face MBCT and individual internet-based eMBCT with a treatment as usual (TAU) group (Cillessen et al., 2018; Compen et al., 2015, 2018). Both MBCT and eMBCT outperformed TAU in reduction of psychological distress (Compen et al., 2018). The focus of the current study is on weekly measures obtained during MBCT and eMBCT. These measures were not obtained during TAU, because the main aim of the trial was to study effectiveness, and to minimalize burden for participants in TAU. Therefore,

Table 1 Descriptive statistics of total BeMind sample and intervention completers included in the current study, separated by condition (MBCT vs. eMBCT)

Variable	Total BeMind sample ($N = 245$)	Intervention completer (≥ 4 sessions, $n = 163$); used in current study	
		MBCT ($n = 84$)	eMBCT ($n = 79$)
Age (M, SD)	51.7 (10.7)	52.6 (10.7)	51.7 (9.9)
Gender (female, *n*, %)	210 (85.7%)	70 (83.3%)	68 (86.1%)
Higher education (yes vs no, *n*, %)	166 (67.8%)	59 (70.2%)	56 (70.9%)
Cancer (breast vs other, *n*, %)	151 (61.6%)	54 (64.3%)	49 (62.0%)
Years since diagnosis (M, SD)	3.5 (4.7)	3.7 (5.3)	3.0 (4.0)
Treatment intent (curative vs palliative, *N*, %)	206 (84.1%)	74 (88.1%)	68 (86.1%)
Depression (*n, %)*	42 (17.1)	14 (16.7%)	17 (21.5%)
Anxiety disorder (*n, %*)	27 (11.0)	9 (10.7%)	7 (8.9%)
Psychological distress at baseline (M, SD)	17.7 (6.6)	18.3 (6.6)	17.3 (7.2)

the current study only focused on the trial arms MBCT and eMBCT, and not on TAU.

MBCT and eMBCT were based on the MBCT program of Segal et al. (2013) and were similar in number of sessions, frequency, and content. The interventions were slightly adapted to fit the needs of cancer patients. Firstly, the psycho-education about stress was replaced by psycho-education about the different phases of grief. Furthermore, information about cancer-related physical symptoms such as fatigue was included. Finally, the movement exercises were adapted for patients with physical limitations, for example, edema. The 8-week (e)MBCT program included weekly sessions (group sessions in MBCT; written information, exercises, and therapist feedback in individual eMBCT). There was a 6-h silent retreat between session six and seven. Patients in eMBCT received instructions to organize their own 6-h silent retreat. Thus, there were nine sessions in total over a time span of 8 to 9 weeks. In addition to the sessions, patients were requested to meditate at home (45 min a day, 6 days a week).

In MBCT, sessions were conducted in face-to-face groups with a maximum of 12 patients per group. The eMBCT program was individual. In eMBCT, each participant was provided with information and exercises involving the theme of the session through a personal, secure webpage. Participants were encouraged to read the information and do the exercises within 1 week. Participants reflected on their experiences by keeping a personal log. The therapist assigned to each participant gave weekly feedback based on this log on a set day of the week, thereby guiding the patient through the program.

Both MBCT and eMBCT were taught by nine qualified mental health care professionals which were also experienced mindfulness teachers. All of them had previous experience with cancer patients and met the criteria of the UK Mindfulness-Based Teacher Network (UK Network for Mindfulness-Based Teachers, 2015). To assess adherence to the protocol and teacher competence, two randomly chosen videotaped sessions were assessed with the MBI-TAC (Crane et al., 2013) by two independent raters. Of the nine rated teachers, two were rated as beginner (22%), three as competent (33%), and four as proficient (44%). No teachers were rated as incompetent. The two teachers at the beginner level only taught one MBCT course each, and no eMBCT.

Prior to randomization, baseline questionnaires were completed. Participants completed the weekly questionnaires before each of the nine sessions of (e)MBCT. MBCT participants completed these questionnaires on paper at the beginning of each group session, while eMBCT participants completed the questionnaires digitally, when starting a new session in the online program.

Patients in the TAU condition were randomly allocated to MBCT or eMBCT after the 3-month TAU period. In the current study, we combined data of patients who were directly randomized to MBCT or eMBCT, and patients who received MBCT or eMBCT after TAU. Further details of the study procedures can be found in the study protocol (Compen et al., 2015).

Measures

The current study focused on data collected in week 1 through week 9 of the intervention. All questionnaires were completed each week. Mindfulness was measured with the Mindful Attention and Awareness Scale (MAAS; Brown & Ryan, 2003; Schroevers et al., 2008). The MAAS assessed different aspects of awareness and attention, which are seen as core characteristics of mindfulness (Brown & Ryan, 2003). It measures the frequency of mindful states. The MAAS has 15 items ("I find it difficult to stay focused on what's happening in the present") that can be answered on a 6-point Likert scale, from "almost never" to "almost always." Higher scores represent higher levels of mindfulness. The MAAS was validated in an oncology sample (Carlson & Brown, 2005), and has good psychometric properties, including internal validity (MacKillop & Anderson, 2007; Schroevers et al., 2008). The average score was used in this study. Internal consistency in the current study was excellent (Cronbach's $\alpha = 0.88$; McDonald's $\omega = 0.87$).

Positive and negative affect were measured with the Positive and Negative Affect Scale – Short Form I (PANAS-SF; Engelen et al., 2006; Thompson, 2007; Watson et al., 1988). The PANAS-SF has 20 items that consist of ten positive and ten negative affective states ("excited" and "nervous"). For each affective state, participants had to indicate on a 5-point Likert scale (from "very slight to not at all" to "extremely") whether they felt this way during the past week. Higher scores represent higher levels of positive and negative affect. Various psychometric aspects of the PANAS-SF including internal reliability, temporal stability, and convergent and criterion-related validities were rated as acceptable (Thompson, 2007). The average scale score was used in this study. Internal consistency in the current study was good for positive affect (Cronbach's $\alpha = 0.79$; McDonald's $\omega = 0.78$), and sufficient for negative affect (Cronbach's $\alpha = 0.66$; McDonald's $\omega = 0.66$).

Data Analyses

To study intervention mechanisms, an adequate treatment dose is required (Kazdin, 2007). Therefore, the current study only included participants who completed at least four sessions of (e)MBCT, which is considered a sufficient dose in MBI literature (Kuyken et al., 2008; Teasdale et al., 2000). Data from participants in MBCT were obtained prior to the weekly group sessions, resulting in a 1-week interval

between the questionnaires. From seven patients, one measurement was excluded from analyses because the questionnaires were completed after the group sessions instead of before, which could interfere with our results. In eMBCT, there was more variability in time between two measurements (M = 9.4 days, SD = 7.8 days), compared to MBCT. To ensure consistency in measurement timing, we excluded one measurement from 18 patients because the interval between assessments was less than 1 day or more than 4 weeks. Thus, we removed seven MBCT and 18 eMBCT datapoints, representing only 2.2% of all datapoints. The total percentage of missing data varied between 18 and 33% per measurement week. Therefore, we utilized analytic procedures that were capable of retaining participants with incomplete data (see below). Calculations of skewness (range 0.167 to 0.723) and kurtosis (range − 0.082 to 0.393) did not reveal any strong violations; therefore, no transformations were used. In the analyses, data of patients that followed MBCT or eMBCT after TAU were combined with data of patients that were initially randomized to MBCT or eMBCT, as there was no difference between these two groups on variables used in our data-analysis (mindfulness, positive and negative affect) or on psychological distress.

Descriptive statistics (means, standard deviations) were calculated in SPSS, version 22 (IBM Corp, 2013). Autoregressive latent trajectory (ALT) models (Bollen & Curran, 2004) were used to estimate latent intercepts and slopes, autoregressive, and cross-lagged effects for mindfulness and positive and negative affect in Mplus version 6 (Muthén & Muthén, 2015). In an ALT model, autoregressive and latent growth curve parameters are combined. This modeling approach enabled us to study general patterns over the 9 weeks (with latent intercepts and slopes) and week-to-week patterns (with autoregressive and cross-lagged paths) simultaneously. The first measurement covaried with the intercept and slope (instead of being part of the estimation of intercept and slope), which is common practice with ALT models to ensure lagged values can be interpreted correctly (Delsing & Oud, 2008; Morin et al., 2011) and to avoid the statistical problem of infinite regression (Morin et al., 2011). Therefore, the intercept should be interpreted as the general initial level accounted for week 1, to which we refer as general level. When performing the ALT models, full information maximum likelihood was employed so participants with incomplete data could be included in the analyzed sample (Enders & Bandalos, 2001).

Building an ALT model requires the fitting of a series of models with and without random slopes and various constraints to find a balance between fit and parsimony. The fit of the models was determined with χ^2, χ^2 divided by the degrees of freedom, (CMIN/df), the comparative fit index (CFI), the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR). For CMIN/df, values below 2 were considered to represent good fit. For CFI and TLI, values above 0.90 are considered adequate, while values above 0.95 are indicative of good fit (Hooper et al., 2008). Previously, RMSEA below 0.05 was a rule of thumb to indicate good fit. However, we followed new guidelines (Hooper et al., 2008) that suggest RMSEA values below 0.07 are indicative of good fit. Furthermore, based on our sample size, an optimal cutoff would lie between 0.05 and 0.06 (Sivo et al., 2006). For SRMR, values below 0.08 and 0.05 are considered adequate and good, respectively (Hooper et al., 2008).

The primary analyses included two multivariate ALT models. The first included mindfulness and positive affect, the second mindfulness and negative affect. We closely followed the analytical steps of Morin et al. (2011) for building the ALT models. We specified a series of increasingly complex models and used χ^2 difference tests to determine whether the more complex model improved the fit to the observed data. When the simpler model demonstrated a better fit (the improved fit of the more complex model was not statistically significant), the former model was retained and compared to subsequent models. Only the most parsimonious models that adequately fitted the observed data are reported here. In these final models, we controlled for intervention type (eMBCT vs. MBCT), by including intervention type as a dichotomous predictor of the latent intercept, slope parameters, and the week 1 measurement. The results of all tested models and all model comparisons are available in Supplementary Materials. All reported results reflect the standardized coefficients.

Results

Table 2 presents the means and standard deviations of the study variables over the nine sessions.

Mindfulness and Positive Affect

The conditional ALT model that demonstrated the best fit to the observed data for mindfulness and positive affect included three sets of equality constraints: all concurrent correlations between weekly measures, all autoregressive paths for positive affect, and all cross-lagged regression paths from positive affect to mindfulness. This model provided adequate to good fit to the observed data ($\chi^2(139) = 202.5$, $p < 0.001$; CMIN/DF = 1.46; CFI = 0.971; TLI = 0.964; RMSEA = 0.054; SRMR = 0.073). We focus our description of the results on model parameters pertaining to the latent structure (intercepts and slopes; Table 3), and autoregressive and cross-lagged regression paths (Fig. 1).

Table 2 Descriptive statistics of mindfulness, positive affect and negative affect during MBCT and eMBCT (combined)

Week	Mindfulness		Positive affect		Negative affect	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
1	3.06	.61	2.83	.72	2.13	.63
2	3.05	.60	2.70	.68	2.10	.73
3	3.21	.58	2.81	.78	2.12	.77
4	3.35	.63	2.88	.72	2.07	.70
5	3.43	.63	2.90	.74	2.09	.72
6	3.53	.62	2.97	.76	2.01	.68
7	3.63	.61	3.01	.77	1.89	.69
8	3.77	.67	3.07	.76	1.87	.71
9	3.85	.63	3.18	.69	1.82	.75

Table 3 Correlations between intercepts and slopes and their descriptives in the final conditional ALT model of mindfulness and positive affect

	1	2	3	4	5	6
1. Intercept mindfulness	–	.61**	.06	−.23	.81**	.59**
2. Intercept positive affect	–	–	.103	.02	.44**	.75**
3. Slope mindfulness	–	–	–	.19	−.01	−.08
4. Slope positive affect	–	–	–	–	−.32*	−.29
5. Mindfulness W1	–	–	–	–	–	.39**
6. Positive affect W1	–	–	–	–	–	–
Estimate	5.33**	5.05**	2.95**	.96*	4.91**	3.80**
Standard error	.55	.58	.58	.49	.41	.37
Residual variance	.98**	1.00**	.99**	.99**	1.00**	1.00**

*$p < .05$, **$p < .001$

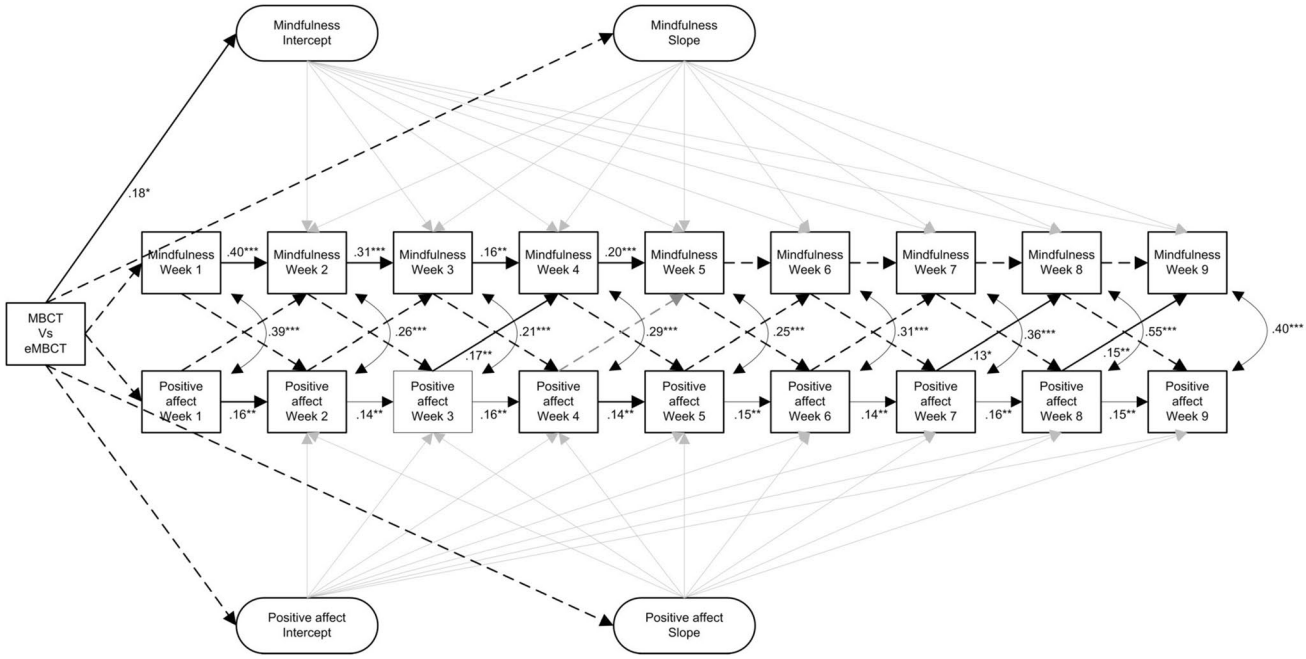

Fig. 1 The conditional ALT model of mindfulness and positive affect. *Note*. Regression paths are presented with arrows; dashed arrows indicate non-significant paths. Correlations are represented by double-headed arrows. For the sake of clarity, only significant correlations are displayed, and error terms and non-significant parameter estimates are not shown. *$p < .05$; **$p < .001$

General Changes

With regard to the latent structure, the slope parameters for both measures were positive and statistically significant (Table 3); mindfulness and positive affect increased throughout the MBCT course. In addition, the intercept parameters were positively correlated; higher general levels of mindfulness were related to increased positive affect. The intercepts of both measures were not correlated with either slope parameter, nor were the slope parameters correlated; general levels of mindfulness and positive affect did not relate to general changes in mindfulness and positive affect.

Weekly Changes

With regard to the model parameters assessing weekly changes, the autoregressive paths for positive affect were statistically significant across all eight periods of change and the autoregressive paths for mindfulness only for the first four periods of change. Thus, after adjusting for the general patterns of change captured by the latent intercept and slope parameters, positive affect exhibited inter-individual stability across the nine weekly assessments, and mindfulness only in the first half of the intervention. With regard to cross-lagged regression paths, three of the eight paths involving positive affect as a predictor of subsequent increases in mindfulness were statistically significant (see Fig. 1), but none of those involving mindfulness as a predictor of subsequent increases in positive affect was statistically significant.

Mindfulness and Negative Affect

The conditional ALT model that demonstrated the best fit for mindfulness and negative affect included five sets of equality constraints: the concurrent correlations between weekly assessments, the autoregressive paths for mindfulness, the autoregressive paths for negative affect, and the cross-lagged paths from mindfulness to negative affect and the cross-lagged paths from negative affect to mindfulness. This model had adequate to excellent fit (χ^2 (153) = 215.0, $p < 0.001$; CMIN/DF = 1.41; CFI = 0.968; TLI = 0.964; RMSEA = 0.051; SRMR = 0.075). Again, we focus our description on model parameters pertaining to the latent structure (Table 4), and autoregressive and cross-lagged regression paths (Fig. 2).

General Changes

With regard to the latent structure, the slope parameters for mindfulness and negative affect were both statistically significant (see Table 4); mindfulness increased and negative affect decreased over the duration of the intervention. Furthermore, the latent intercepts were negatively correlated; a higher general level of mindfulness is related to a lower general level of negative affect. The intercepts of both mindfulness and negative affect were also associated with the slope parameter for negative affect. The positive correlation involving the intercept of mindfulness reveals that higher general levels of mindfulness were related to less pronounced general decreases in negative affect. The negative correlation between the intercept and slope parameters of negative affect indicates that higher general levels of negative affect were associated with more pronounced decreases in negative affect. Furthermore, the slope parameters were also significantly correlated indicating that stronger increases in mindfulness were related to stronger decreases in negative affect.

Weekly Changes

With regard to the model parameters assessing weekly changes, all autoregressive paths for mindfulness and negative affect were positive and statistically significant, so mindfulness and negative affect demonstrated inter-individual stability. The cross-lagged regression paths involving mindfulness as a predictor of changes in negative affect were statistically significant across all eight periods of change, with higher levels of mindfulness related to higher levels

Table 4 Correlations between intercepts and slopes and their descriptives in the final conditional ALT model of mindfulness and negative affect

	1	2	3	4	5	6
1. Intercept mindfulness	–	−.53**	−.22	.29*	.85**	−.35**
2. Intercept negative affect	–	–	.16	−.47**	−.50**	.63**
3. Slope mindfulness	–	–	–	−.75**	−.37**	−.003
4. Slope negative affect	–	–	–	–	.38**	−.10
5. Mindfulness W1	–	–	–	–	–	−.35**
6. Negative affect W1	–	–	–	–	–	–
Estimate	5.49**	2.77**	1.37**	−.82*	4.92**	3.82**
Standard error	.58	.68	.38	.37	.41	.32
Residual variance	.97**	.98**	1.00**	1.00**	1.00**	.97**

*$p < .05$, **$p < .001$

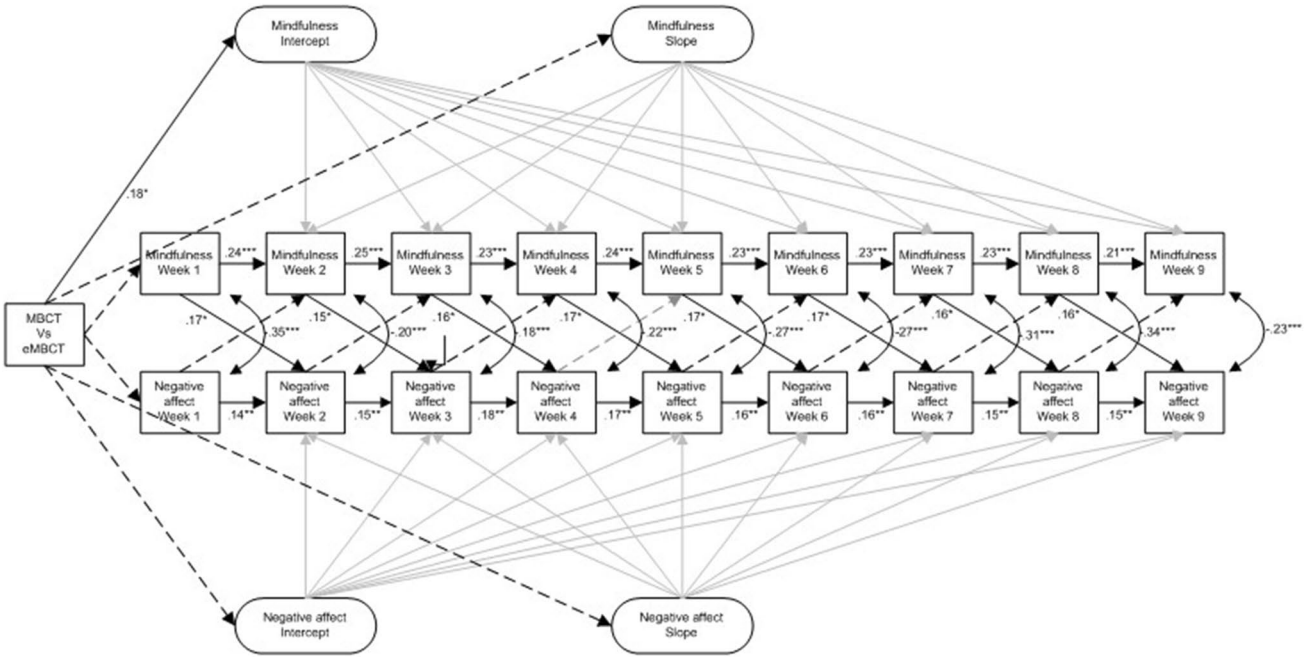

Fig. 2 The conditional ALT model of mindfulness and negative affect. *Note.* Regression paths are presented with arrows; dashed arrows indicate non-significant paths. Correlations are represented by double-headed arrows. For the sake of clarity, only significant correlations are displayed, and error terms and non-significant parameter estimates are not shown. $*p<.05$; $**p<.001$

of negative affect in the subsequent week. The cross-lagged paths involving negative affect as a predictor of changes in subsequent mindfulness were not statistically significant.

Discussion

The current study aimed to evaluate general and week-to-week changes in mindfulness and positive and negative affect, and their interrelations during MBCT and eMBCT in cancer patients. To do so, autoregressive latent trajectory models were applied to weekly assessments of mindfulness and affect during MBCT for cancer patients.

We found that general levels (intercepts) of mindfulness and positive affect were related, and that mindfulness and positive affect both increased during MBCT (slopes). This corresponds with previous research (Schroevers & Brandsma, 2010). General increases in mindfulness and positive affect over MBCT were however not related to each other. Positive affect in 1 week predicted positive affect in the subsequent week, while this was not always the case for mindfulness. This may suggest that the general increase in mindfulness might be fully accountable for the week-to-week differences. Furthermore, we did not found week-to-week relations from mindfulness to positive affect but we did observe some from positive affect to mindfulness.

Regarding the relationship between mindfulness and negative affect, we observed a general tendency for mindfulness to increase, and for negative affect to decrease, which is in accordance with previous research (Schroevers & Brandsma, 2010). We also found that these slopes were related to one another. In addition, higher general levels of mindfulness were related to a smaller decrease of negative affect, which could be due to a bottom effect (those with high mindfulness at the start were also low in negative affect). However, the week-to-week timeframe revealed a different picture: higher levels of mindfulness in 1 week were related to increased negative affect in the subsequent week. Increases in mindfulness may lead to increased allowing of previously suppressed negative affect, which is further explained below.

Some of our findings contrast with previous research. The absence of a time-bound relation between mindfulness and positive affect is in contrast with previous findings from Snippe et al. (2015). They found that daily measures of mindfulness predicted increases in positive affect the following day in the general population, but not vice versa. They also found that higher levels of mindfulness on a certain day were related to less negative affect, while we found the opposite; mindfulness in a certain week was related to increased negative affect in the subsequent week. Furthermore, ter Avest et al. (2020), using a similar design and analyses as ours in recurrently depressed patients, showed that general increases in mindfulness and positive affect over MBCT were related, which we did not observe. In addition, they found no week-to-week associations between mindfulness and negative affect.

Differences between previous studies and our results include different samples (cancer patients vs. general population vs. depressed patients), questionnaires (MAAS vs. Five Facet Mindfulness Questionnaire (de Bruin et al., 2012)), analysis (ALT models vs. autoregressive multilevel models), or assessment timing (weekly vs. daily). Of these, the only aspect in which our study differs from the two studies above is the sample, and there are possible reasons why mechanisms in cancer patients may be different to those in healthy or depressed populations.

Oncology patients might have avoided negative emotions to help them cope with the physical consequences of both their illness and the medical treatments (Hayes et al., 2011). After anti-cancer treatment is finished; however, continued avoidance might impede the emotional processing of the experience. This might cost a significant amount of energy and may lead to psychological distress, and for some even to a depressive or anxiety disorder. An important aspect of MBCT is turning towards the difficult. Therefore, mindfulness can help to gently turn towards distress and uncertainty related to cancer and its consequences (Brown et al., 2007; Roemer et al., 2015; Treanor, 2011). Furthermore, we observed that positive affect in some of the weeks resulted in increased mindfulness in the subsequent week. This finding is in correspondence with previous research in depressed patients (ter Avest et al., 2020), and may suggest that positive affect facilitates mindfulness.

For cancer patients and survivors, experiential exposure in MBCT may result in a short-term increase of negative affect (Cayoun, 2011), as shown by our week-to-week results.

In the long run, however, these emotions may reduce due to experiential exposure, supported by acceptance, self-compassion, or an improved ability to tolerate negative affect (Brown et al., 2007; Treanor, 2011). This might show in the general decrease in negative affect over MBCT as found in our study.

It may be possible that affect changes differently in cancer patients compared to depressed patients. Ter Avest et al. (2020) found a standardized slope coefficient of 0.80 for the relation between increases in mindfulness and increases in positive affect, while the slope decrease in negative effect was removed from the model as it did not explain a sufficient amount of variance. In the current study in oncology patients, we found a reciprocal pattern, with a standardized slope coefficient of 0.19 (not significant) for the relation between increases in mindfulness and positive affect, and a significant standardized slope coefficient of − 0.75 for the relation between increases in mindfulness and decreases in negative affect. Thus, it is possible that changes in negative affect are more common as working mechanism in cancer patients, and changes in positive affect are more likely in depressed patients. Working mechanisms may differ in various patient groups, although this needs to be investigated in a comparative study.

Obviously, our findings will need to be replicated before they can guide clinical practice. However, these new insights may help mindfulness teachers to inform cancer patients that a mindfulness training will involve allowing rather than avoiding difficult emotions. This might improve expectation management before and during the training. Patients who are aware the training could be difficult at times may feel better equipped when encountering negative feelings or increases of symptoms.

Limitations and Future Research

The current study has several strengths. A major strength is the statistical model we used. The ALT models enabled us to simultaneously disentangle general and week-to-week patterns. Therefore, week-to-week patterns were controlled for general tendencies in the data, and the other way around. Without these controls, results could provide an incomplete or even incorrect picture of mechanisms (Voelkle, 2008). Specifically, we would not have been able to observe time-related differences in the association between mindfulness and negative affect when using regular mediation models. A second strength of the current study are the repeated measures of our mediators during the intervention.

Some limitations should be mentioned as well. We worked with weekly measures, as we could easily administer these at the start of the MBCT sessions. However, it is possible that the week-to-week timeframe was too crude, resulting in a lack of significant findings on cross-lagged paths. Day-to-day or even moment-to-moment assessments might be better able to capture the influence mindfulness and affect may have on each other (for example, Gotink et al., 2016; Snippe et al., 2015). Secondly, we lacked weekly measures of a control group, as we considered it to be too burdensome for patients in TAU to complete weekly measures. Therefore, we cannot be sure whether time patterns observed are due to (e)MBCT, or whether these are processes naturally occurring over time. However, we did find increases in mindfulness and decreases of psychological distress in eMBCT and MBCT compared to treatment as usual in the main RCT (Compen et al., 2018). Thirdly, some criticism has been expressed regarding the questionnaires we used. Although the MAAS is commonly used, its validity has been criticized due to statements being formulated in a negative way (reflecting mindlessness) and its restriction to measuring mindful attention and awareness (Grossman, 2011). The PANAS, on the other hand, has been criticized for including only high arousal emotions (Forgeard et al., 2011), while mindfulness especially increases lower arousal positive emotions, like calmness (Jones et al., 2018). Fourthly, although most involved mindfulness teachers were competent, two

teachers were rated as beginner. They only provided MBCT for a small portion of participants (< 10). Finally, although the parent trial of this study has sufficient power (0.9; Compen et al., 2018), we did not do an a priori power analysis for these analyses. As a consequence, power may be compromised in our analyses.

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Author Contribution LC: analyzed the data and wrote the paper. MV: collaborated with analyzing the data and writing. EB: executed the study and collaborated with writing. FC: executed the study and collaborated with writing. WB: collaborated with analyzing the data and writing the results. ML: designed the study, and collaborated with writing of the paper. AS: designed the study, and collaborated with writing of the paper. All authors approved the final version of the manuscript for submission.

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Data Availability Data are available from the Radboud Center for Mindfulness upon reasonable request.

Declarations

Ethics Approval This study was approved by the ethical review board of the Radboud University Medical Center (CMO Arnhem-Nijmegen, 2013/542).

Consent to Participate The current research involves human participants, who all provided written informed consent prior to their participation.

Conflict of Interest LC, EB, and FC were employed by the Radboudumc Center for Mindfulness when conducting this study. AS is the director of the Radboudumc Center for Mindfulness.

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