Understanding change in psychological treatments for depressive symptoms
Snippe, Evelien

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The temporal order of change in daily mindfulness and affect during Mindfulness-Based Stress Reduction

E. Snippe, I. Nyklíček, M.J. Schroevers, E.H. Bos

Submitted
THE TEMPORAL ORDER OF CHANGE

Abstract

Background. Increases in mindfulness are assumed to lead to improvements in psychological wellbeing during mindfulness-based treatments. However, the causal direction of this association never been adequately tested. This intensive longitudinal study examines whether within-person changes in mindfulness precede or follow changes in negative affect (NA) and positive affect (PA) during a Mindfulness Based Stress Reduction (MBSR) program. Also, inter-individual differences in the association between mindfulness and affect are investigated.

Methods. Mindfulness, NA, and PA were assessed on a daily basis in 83 individuals from the general population who participated in an MBSR program. Multilevel autoregressive models were used to investigate the temporal order of change in mindfulness and affect.

Results. Day-to-day changes in mindfulness predicted subsequent day-to-day changes in both NA and PA, but reverse associations did not emerge. The magnitude of the effects differed substantially between individuals. Furthermore, mindfulness home practice during the day predicted subsequent increases in mindfulness.

Conclusions. Changes in mindfulness seem to precede rather than to follow changes in affect during MBSR. Yet, the strength of the relationship between mindfulness and affect is not the same for all participants. The findings suggest that increasing mindfulness on a daily basis may be a beneficial means to improve daily psychological wellbeing.
Mindfulness involves the ability to be aware of present-moment experiences and observing these experiences as they are instead of judging them (Bishop et al., 2004; Brown et al., 2007; Kabat-Zinn, 1994). Responding mindfully to experiences in daily life is assumed to be beneficial for one’s well-being because it may enhance emotion regulation (Chambers et al., 2009; Hoelzel et al., 2011) and decrease negative cognitive responses (Segal et al., 2002). In observational studies, mindfulness has been associated with state and trait measures of psychological wellbeing, including negative correlations with measures of distress, anxiety, and depression, as well as positive associations with positive affect measures (e.g., Baer et al., 2006; Brown & Ryan, 2003). In addition, mindfulness-based interventions have been found to decrease symptoms of stress, anxiety, and depression as well as to improve quality of life and positive affect (e.g., Nyklíček & Kuijpers, 2008; Schroevers & Brandsma, 2010; see also reviews by Hofmann et al., 2010; Khoury et al., 2013).

Although the evidence suggests that cultivation of mindfulness is associated with psychological well-being, the causal direction of this association is unclear. The prevailing way to test whether mindfulness leads to increases in psychological wellbeing has been to examine whether a pre-to post-treatment change in mindfulness statistically mediates the pre-post treatment change in psychological wellbeing. Several studies indeed showed that mindfulness statistically mediates the effects of mindfulness-based treatments on measures of psychological wellbeing (Bränström, Kvillemo, Brandberg, & Moskowitz, 2010; Carmody & Baer, 2008; Heeren et al., 2014; Jislin-Goldberg, Tanay, & Bernstein, 2012; Nyklíček & Kuijpers, 2008; Shahar et al., 2010; Shapiro, Oman, Thoresen, Plante, & Flinders, 2008; Vøllestad, Sivertsen, & Nielsen, 2011), although in two studies this mediation effect was not found consistently (Labelle, Campbell, & Carlson, 2010; van Aalderen et al., 2012).

An important limitation of the above studies is that they do not allow the investigation of the temporal order of change in mindfulness and psychological wellbeing. Clarity about the temporal order of change is a first prerequisite for making inferences regarding the causal direction of an association. A change in the assumed mechanism (e.g., mindfulness) should therefore temporally precede a change in the outcome (e.g., psychological wellbeing) (Kazdin, 2007; Kraemer, Wilson, Fairburn, & Agras, 2002). This cannot be examined in standard pre-post treatment designs with only two measurement points, because change in the presumed mediator and outcome are assessed at the same moment in time. Alternative explanations for the found associations are therefore still plausible. For
example, the causal direction may be the reverse: improvements in psychological wellbeing may lead to increases in mindfulness. Improvements in psychological wellbeing may be caused by other factors, such as self-efficacy or social support obtained during mindfulness-based treatment, and subsequently enhance the ability to establish a state of mindfulness (Bishop, 2002). The relationship may also be reciprocal, with small increases in either mindfulness or wellbeing generating a positive feedback loop (Baer, Carmody, & Hunsinger, 2012).

The study of mechanisms of change calls for suitable methodologies to be able to draw conclusions about the temporal order of change within individuals (Hofmann, Asmundson, & Beck, 2013; Kazdin & Nock, 2003). The designs of most studies done thus far are not suitable to examine processes that operate within individuals because the number of time points is too low (Curran & Bauer, 2011; Hamaker, 2012; Molenaar, 2004). Two studies did assess mindfulness and affect repeatedly during the course of a mindfulness-based treatment (Baer et al., 2012; Vøllestad et al., 2011), but the frequency of assessments in these studies was still not high enough to enable proper estimation of within-subject associations.

Finally, there is a lack of knowledge on possible heterogeneity between individuals in the dynamic interplay between mindfulness and psychological well-being. The findings of a previous replicated single-subject time-series study suggested some heterogeneity in the lagged associations between mindfulness, repetitive thinking, and depressive symptoms during a mindfulness-based treatment (Snippe et al., submitted). Day-to-day increases in mindfulness were followed by decreases in depressive mood in one out of six participants, while no reverse effects were found.

Intensive longitudinal designs have been put forth as the method of choice to study within-person processes, because they allow to disaggregate within-person and between-person associations, and therefore they allow examining true within-subjects effects (Bolger & Laurenceau, 2013; Curran & Bauer, 2011; Hamaker et al., 2005). Because of the multitude of repeated measurements, these designs are very suitable to investigate whether increases in mindfulness consistently precede or follow changes in psychological wellbeing within individuals. In addition to that, inter-individual differences in these dynamic associations can be examined using intensive longitudinal designs.

In sum, the evidence so far is not compelling regarding the assumption that increases in mindfulness induce improvements in psychological wellbeing in daily life rather than the other way around, as there is a lack of studies suitably designed to investigate this. The current study
examined the within-person temporal order of change in daily observations of mindfulness and psychological wellbeing using an intensive longitudinal design. This was investigated within the context of a Mindfulness-Based Stress Reduction (MBSR) program, because day-to-day variability in mindfulness is more likely to be observed within such a context. For the assessment of psychological wellbeing, we measured both negative affect (NA) and positive affect (PA), as these are considered the dominant and relatively independent dimensions of emotional experience (Watson, Clark, & Carey, 1988; Watson & Tellegen, 1985). We examined whether day-to-day changes in mindfulness precede or follow day-to-day changes in PA and NA during an MBSR program. We also examined inter-individual differences in the temporal order of change, to gain more insight into possible heterogeneity between individuals in the mechanism of change. To check whether mindfulness practice assigned in the MBSR program is associated with changes in mindfulness, we examined whether daily mindfulness home practice predicts increases in daily mindfulness.

Method

Participants and procedure
Participants were recruited between January 2010 and June 2012 by means of a website and advertisements in the local newspapers of Tilburg, The Netherlands. The MBSR intervention was advertised as a group intervention to reduce feelings of distress by means of cultivating mindfulness. The accompanying diary study was promoted by offering a 10% discount on the MBSR intervention to those willing to participate in the diary study. An online screening was performed to examine potential exclusion criteria, if necessary supplemented by a telephone interview. Exclusion criteria were severe psychiatric disorders (e.g., current severe major depression episode, suicidal, or psychotic tendencies) and an inability to read and write in Dutch.

Before the start of the intervention, participants were asked to fill out an online pre-treatment questionnaire. After the first MBSR session, participants were instructed to fill out the daily questions online after 5 PM each day until the day of the last session of the treatment. Participants were told that they were allowed to miss one entry per week. During the study, the frequency of completing the questions was monitored and if lower than 6 entries per week, participants received an e-mail reminder to be more adherent.

None of the individuals interested in the MBSR program were excluded because of presence of exclusion criteria. Of the 187 individuals
who participated in the MBSR program during the study period 85 individuals (47%) agreed to participate in the diary study. Two of these individuals filled out the diary measures on only 2 days and where therefore excluded from the analyses. The final sample of 83 participants all provided written informed consent.

**Intervention**
The provided Mindfulness-Based Stress Reduction (MBSR) program is the manualized group program by Jon Kabat-Zinn (1990). The MBSR program consists of 8 sessions over 8 to 9 weeks of 2½ hours, an optional silent retreat session of 6 hours, and daily homework practice of at least 40 minutes. The MBSR program is aimed at training mindfulness by means of meditation practice (e.g., body scan and sitting meditation), yoga, psycho-education (e.g., automatic versus mindful response) and group sharing of experiences during the practices. In these mindfulness practices, participants are instructed to observe their experiences, recognize when their attention drifts away and to redirect their attention to their experiences in a non-judgmental way. During the study period, 16 groups of 8-14 participants were run by a qualified psychologist who received extensive training in MBSR and is certified by the Dutch association for Mindfulness (VVM). This trainer had almost five years of experience as an MBSR trainer at the start of the study period and provided on average five classes per year.

**Measures**

**Baseline assessment**
The pre-intervention questionnaire included questions on demographic and clinical variables. Affect, stress and mindfulness were assessed with full-scale self-report questionnaires at baseline. Negative Affect (NA) and Positive Affect (PA) were assessed using the short form of the Profile of Mood States (POMS-SF), a frequently used questionnaire developed to assess transient mood states (Shacham, 1983). The Dutch version of the POMS-SF consists of 32 self-report items covering 5 subscales (Wald & Mellenbergh, 1990). The subscales Depression, Anger, Fatigue, and Tension were used to measure NA and the Vigor subscale was used to measure PA. Each item is rated on a 5-point Likert scale ranging from 1 (not at all) to 5 (extremely). The psychometric properties of the POMS-SF are good (Baker, Denniston, Zabora, Polland, & Dudley, 2002; Wald & Mellenbergh, 1990). The internal consistency of the subscales is high in our sample: the lowest value of Cronbach's alpha is 0.82.

Mindfulness was assessed using the Five Facet Mindfulness Ques-
tionnaire (FFMQ) (Baer et al., 2008; Baer et al., 2006). The questionnaire consists of 39 items that address 5 facets of mindfulness: observing, describing, acting with awareness, non-judging of inner experience, and non-reactivity to inner experience. Each item is rated on a 5-point Likert scale ranging from 1 (never or very rarely true) to 5 (very often or always true). The psychometric properties of the FFMQ are adequate (Baer et al., 2008; Baer et al., 2006). In our study, the Cronbach’s alpha of the FFMQ facets range from 0.68 to 0.92.

Daily assessment
For the daily assessments, we selected items from validated questionnaires with high loadings on the corresponding subscale (based on previous findings) in combination with their applicability in daily life. Only two items were selected per subscale because it has been recommended to use short questionnaires in diary research (Thiele et al., 2002) as lengthy questionnaires may induce unreliable automatic responses, reduce compliance (Morren et al., 2009), and result in dropout (Thiele et al., 2002). Two items were selected of each subscale of the POMS-SF based on high factor loadings found by Baker and colleagues (2002). For negative affect, eight items in total were included: blue and miserable (Depression), angry and peeved (Anger), tense and nervous (Tension), fatigued and exhausted (Fatigue). As Vigor is the only positive affect subscale of the POMS-SF, we selected three instead of two items to be able to assess positive affect reliably, namely, energetic, lively, and cheerful. We added two extra positive affect items that we considered relevant but were missing in the POMS-SF: relaxed and happy. The Negative Affect (NA) and Positive Affect (PA) scores were calculated by taking the mean of the 8 respectively 5 mentioned items. The composite NA and PA scores can range from 1 to 5. The internal consistency of the scales was sufficient. For the first day of the measurement period, Cronbach’s alpha was 0.84 for NA and 0.88 for PA.

For the daily mindfulness measure, we selected two items for each facet of the FFMQ, again based on high loadings on the corresponding subscale in previous research (Baer et al., 2006). The chosen items were the original items 1 and 20 for Observing, items 12 and 16 for Describing, 23 and 28 for Acting with Awareness, 30 and 39 for Non-judging and 9 and 33 for Non-reacting. To make the items suitable for daily assessment, we reworded the items slightly to reflect relevance to the day that just passed. A total score for mindfulness was constructed by calculating the mean of the 10 items (range 1 to 5). The Cronbach’s alpha of the daily mindfulness measure was 0.81 on the first day of the study. Also, the total of these 10
items assessed at baseline correlated highly with the total FFMQ score assessed at baseline \( r = 0.93 \), which is an indication for adequate content validity.

As a measure of daily mindfulness practice, the following question was included in the diary: ‘Did you already do a formal mindfulness exercise today?’ The answer categories included ‘yes’ and ‘no, not yet’. The question was asked after the daily mindfulness and mood questions.

**Statistical analysis**

We investigated whether within-person changes in mindfulness precede and predict within-person changes in NA and PA, and/or the other way around. Four autoregressive multilevel models (see Rovine & Walls, 2006) were specified using the STATA xtmixed command. In a first model, it was tested whether values of NA at each time point \( t \) could be predicted by lagged values of mindfulness \( t-1 \), controlling for lagged values of NA \( t-1 \). In a second model, the reverse lagged association was tested, i.e., whether values of mindfulness at each time point \( t \) could be predicted by lagged values of NA \( t-1 \), controlling for lagged values of mindfulness \( t-1 \). Two similar models were specified to test the cross-lagged associations between mindfulness and PA. A lag of one day was specified as it seems likely that if mindfulness affects PA and NA, it will show the next day rather than after two days. An additional multilevel model was specified to test whether values of mindfulness at each time point \( t \) could be predicted by practice of at least one mindfulness exercise during that day, controlling for lagged values of mindfulness \( t-1 \).

Because a decrease or increase in the variables over time may induce spurious correlations among the variables (Rovine & Walls, 2006), any trends in the diary data were removed before the analyses were performed. To separate within-subject effects from between-subject effects, we used the recommended approach of person-mean centering of the predictor variables, by calculating daily within-person deviations from the person’s mean (Bolger & Laurenceau, 2013; Curran & Bauer, 2011). The coefficients were allowed to differ across individuals by modeling them as random effects, to gain insight into the heterogeneity of the effects. To visualize this between-subject variation in the within-subject effects, individual coefficients were predicted by Best Linear Unbiased Prediction (BLUP) and presented in histograms (Rabe-Hesketh & Skrondal, 2008).

The concurrent (same-day) associations were not included in the autoregressive models. This was done to separate the dynamic from the simultaneous part of the model, because the temporal order of the latter
associations is not clear (Brandt & Williams, 2007). To provide insight in the concurrent associations, the residuals of the autoregressive multilevel models were saved and correlated.

Because the diary series of some participants where either short or contained a lot of missing data (18% on average), the results of all 83 participants were compared with the results of 46 ‘compliant participants’. Participants were considered compliant if the series covered at least 45 days, with observations on at least 80% of the days. The 83 study participants provided 3355 diary entries of which 3236 were included in the analyses; the other 119 observations were considered invalid because the questionnaires were filled out before 5 PM or after 4 AM the next day. The length of the individual series ranged between 10 and 62 days, with an average of 47 days (SD = 10.6).

**Results**

*Characteristics of the participants*

Table 1 displays the characteristics of the study participants at baseline. The majority of the sample was female, highly educated and received treatment for psychological problems in the past. The 46 compliant participants did not differ from the non-compliant participants regarding demographic variables, levels of mindfulness, and the POMS-SF at baseline.
Table 1. Baseline characteristics of the participants

<table>
<thead>
<tr>
<th>Variable</th>
<th>M/% (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>40.6 (10.0)</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td>69.5%</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
</tr>
<tr>
<td>Lower vocational/primary school</td>
<td>2.4%</td>
</tr>
<tr>
<td>Vocational/secondary school</td>
<td>36.6%</td>
</tr>
<tr>
<td>Higher post-education/college</td>
<td>61.0%</td>
</tr>
<tr>
<td><strong>Employed, full-time or part-time</strong></td>
<td>78.0%</td>
</tr>
<tr>
<td><strong>Married or living together</strong></td>
<td>61.0%</td>
</tr>
<tr>
<td><strong>Chronic somatic disease</strong></td>
<td>28.1%</td>
</tr>
<tr>
<td><strong>Past psychological treatment</strong></td>
<td>62.2%</td>
</tr>
<tr>
<td><strong>Current use of antidepressant</strong></td>
<td>16.6%</td>
</tr>
<tr>
<td><strong>POMS-SF</strong></td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>18.7 (7.3)</td>
</tr>
<tr>
<td>Anger</td>
<td>16.3 (6.4)</td>
</tr>
<tr>
<td>Tension</td>
<td>16.9 (5.2)</td>
</tr>
<tr>
<td>Fatigue</td>
<td>16.3 (6.4)</td>
</tr>
<tr>
<td>Vigor</td>
<td>13.0 (4.1)</td>
</tr>
<tr>
<td><strong>FFMQ</strong></td>
<td></td>
</tr>
<tr>
<td>Observing</td>
<td>24.1 (4.4)</td>
</tr>
<tr>
<td>Describing</td>
<td>27.2 (5.6)</td>
</tr>
<tr>
<td>Acting with awareness</td>
<td>21.3 (4.7)</td>
</tr>
<tr>
<td>Non-judging</td>
<td>22.9 (7.0)</td>
</tr>
<tr>
<td>Non-reacting</td>
<td>18.0 (4.9)</td>
</tr>
</tbody>
</table>

*Note.* POMS = Profile Of Mood Scale-SF subscales, FFMQ = Five Facet Mindfulness Questionnaire, N = 82.
Model 1: Do changes in mindfulness precede changes in NA?
Consistent with our hypothesis, the fixed effects of the multilevel model for NA indicated that within-person changes in mindfulness preceded changes in NA. That is, higher levels of mindfulness on a certain day were followed by lower levels of NA the next day (β = -0.10, 95% CI = -0.16 to -0.04, p = 0.03; see Model 1, Table 2). The random effects showed significant variability between subjects in the effect of mindfulness on NA. The variation around the Mindfulness (t-1) slope was 0.012, corresponding with 0.108 standard deviations. On the basis of this standard deviation, it can be estimated that 95% of the population has coefficients between -0.31 and 0.11 for the effect of mindfulness on NA. Based on the Best Linear Unbiased Prediction (BLUP), a smaller range of between-subject variability was predicted (see Figure 1).

Model 2: Reversing the order: do changes in NA precede changes in mindfulness?
Changes in NA did not predict subsequent changes in mindfulness (β = 0.00, 95% CI = -0.03 to 0.03, p = .96; see Model 2 in Table 2). The random effect of lagged values of NA on mindfulness was non-significant and removed from the model to improve model fit.

Model 3: Do changes in mindfulness precede changes in PA?
The third model showed that changes in mindfulness preceded changes in PA. That is, increases in mindfulness were followed by increases in PA the next day (β = 0.07, 95% CI = 0.004 to 0.14, p = 0.04; see Model 3 in Table 2). The random effects indicated variability between subjects in the lagged effect of mindfulness on PA, with estimated slopes ranging between -0.08 and 0.22 in approximately 95% of the population. A smaller range of between-subject variability was indicated based on BLUP, which showed only positive coefficients for the lagged effect of mindfulness on PA (see Figure 1).

Model 4: Reversing the order: do changes in PA precede changes in mindfulness?
The last model indicated that there were no reverse effects in the current sample. Changes in PA were not followed by changes in mindfulness the next day (β = 0.00, 95%, CI = -0.03 to 0.02, p = 0.90). The random effect of lagged values of PA on mindfulness was non-significant and removed from the model to improve model fit.
**The Temporal Order of Change**

*Model 5: does daily mindfulness practice predict changes in mindfulness?*  
On average, home practice of at least one mindfulness exercise during the day was followed by higher levels of mindfulness in the evening ($B = 0.03$, 95% CI = 0.01 to 0.05, $p < 0.01$) (not shown in a table). The random effect of mindfulness practice was non-significant and omitted to improve model fit.

*Model 1-5: Results in compliant sample*  
Re-running the models on the data of the sub-sample of 46 compliant participants showed that the fixed effects were similar to those found in the total sample; increases in mindfulness were followed by decreases in NA ($B = -0.09$, 95% CI = -0.16 to -0.02, $p < 0.01$) and increases in PA ($B = 0.07$, 95% CI = 0.001 to 0.16, $p = 0.046$) the next day. Reverse effects were not found; changes in mindfulness were not predicted by previous changes in NA ($B = 0.01$, 95% CI = -0.03 to 0.05, $p = 0.56$) or PA ($B = -0.01$, 95% CI = -0.04 to 0.02, $p = 0.51$). Also, mindfulness practice during the day was followed by increases in mindfulness ($B = 0.03$, 95% CI = 0.01 to 0.05, $p < 0.01$) in the compliant sample.

*Concurrent associations between mindfulness, NA and PA.*  
Strong concurrent (same-day) correlations were found among the variables. The same-day correlation between mindfulness and NA was -0.47, and the correlation between mindfulness and PA was 0.45. These correlations were controlled for the lagged associations by using residuals of the four autoregressive multilevel models.
### Table 2. Estimates from the autoregressive multilevel models

<table>
<thead>
<tr>
<th>Outcome</th>
<th>NA Model 1</th>
<th>Mindfulness Model 2</th>
<th>PA Model 3</th>
<th>Mindfulness Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>1.78 (.06)**</td>
<td>3.31 (.05)*</td>
<td>2.59 (.07)**</td>
<td>3.31 (.05)**</td>
</tr>
<tr>
<td>Mindfulness t-1</td>
<td>-0.10 (.03)**</td>
<td>0.14 (.03)*</td>
<td>0.07 (.04)*</td>
<td>0.23 (.03)**</td>
</tr>
<tr>
<td>NAt-1</td>
<td>0.14 (.03)**</td>
<td>-0.00 (.02) ns.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA t-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Random-effect variances</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 2 (between-person)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>0.251 (.040)**</td>
<td>0.203 (.032)*</td>
<td>0.439 (.070)**</td>
<td>0.204 (.032)**</td>
</tr>
<tr>
<td>Mindfulness t-1</td>
<td>0.012 (.010)*</td>
<td>0.015 (.007)*</td>
<td>0.006 (.012)*</td>
<td>0.017 (.007)*</td>
</tr>
<tr>
<td>NAt-1</td>
<td>0.018 (.007)*</td>
<td>omitted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PA t-1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 1 (within-person)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual</td>
<td>0.173 (.005)**</td>
<td>0.101 (.003)*</td>
<td>0.025 (.007)**</td>
<td>0.100 (.003)**</td>
</tr>
</tbody>
</table>

N/observations: 83/2669 83/2671 83/2669 83/2671

**Note.** **p<0.01, p< 0.05, ns. = non-significant, NA = Negative Affect, PA = Positive Affect, N = number of participants. Estimates are unstandardized coefficients (B). Between parentheses: standard error of the estimate (SE). Omitted = random effects omitted from the model because of non-significance.
Figure 1. Between-subject variation in the within-subject effects of mindfulness on affect

Note. BLUP = Best Linear Unbiased Prediction
Discussion
To gain more insight into the direction of the association between mindfulness and psychological wellbeing, we examined the temporal order of within-person changes in mindfulness and negative affect (NA) as well as positive affect (PA) over the course of an MBSR program. Day-to-day changes in mindfulness predicted subsequent day-to-day changes in both NA and PA. Our results did not support reverse causality; changes in NA and PA did not predict subsequent changes in mindfulness. Furthermore, mindfulness home practice during the day predicted subsequent increases in mindfulness. The findings held both in the total sample and in a subsample of compliant individuals. These results provide empirical support for the assumed role of mindfulness in reducing NA and enhancing PA in daily life during mindfulness-based treatment.

Our findings imply that when an individual's levels of mindfulness are increased, this is followed by improvements in NA and PA for at least one day. It is of interest that changes in mindfulness seem to precede changes in both negative affect and positive affect, as these mood states have been shown to be relatively independent (Watson & Tellegen, 1985). When one does not feel blue or tense, this does not necessarily imply that one is energetic or cheerful. It is therefore an important finding that observing one's experiences in an aware, non-judgmental and non-reacting way may be followed by feelings of liveliness and cheerfulness besides reduced feelings of anger, fatigue, or tension the next day.

The results suggest that the relationship between mindfulness and affect is not reciprocal, implying that increases in mindfulness are not merely a side effect of improved mood. Increases in mindfulness preceded improvements in psychological wellbeing rather than the other way around. Emphasis of the value of practicing mindfulness skills by mindfulness trainers therefore does not seem superfluous, as such skills indeed seem beneficial for one's daily wellbeing. Our study also showed that daily mindfulness home practice predicted increases in mindfulness, making a strong case that mindfulness can be improved by mindfulness home practice. However, people may also become more mindful because of other reasons, for example, because of working in a vegetable garden. Thus, the observed sequence of changes may also occur outside a treatment context. Future studies are encouraged to examine the studied associations in other contexts.

The aim of this study was not only to investigate 'average' lagged associations, but also to examine inter-individual differences in the found effects. The random effect variances indicated considerable individual
differences in the magnitude of the lagged effect of mindfulness on NA and PA, and also covered some associations with an opposite sign, for example, positive associations between mindfulness and NA. The individual coefficients as predicted by the BLUPs showed a smaller range of variation, which is as expected since BLUPs are shrunken towards the population mean (Rabe-Hesketh & Skrondal, 2008). It remains a matter of debate whether or not random effect models can capture such inter-individual differences adequately (Gates & Molenaar, 2012). The BLUP predictions are based on the assumption of a normal distribution of the random effects, which may result in biased estimates in case of substantial heterogeneity. A unit-by-unit approach, by using single-subject time-series analyses, may therefore be a preferable alternative when between-subject heterogeneity is large and the number of time points is sufficient (Horvath & Wieringa, 2008).

Nevertheless, the degree of heterogeneity found in the present study indicates that the found average temporal associations do not generalize to all individuals. This may be due to differential strength of the associations or differences in the duration of the effects. In the former case, people differ in the strength of the association between daily mindfulness and subsequent affect. In the latter case, it may be that the effect of daily increases in mindfulness does not last until the next day in some persons. Future studies including within the day assessments may shed light on this question.

The inter-individual differences found in the present study may also explain why changes in mindfulness predicted changes in depressive mood in only one of the six participants in our previous single-subject time-series study (Snippe et al., submitted). Consistent with our current findings, this previous study did not find evidence for reverse effects; changes in depressive symptoms did not predict changes in mindfulness in any of the six participants. The study also showed strong concurrent (same-day) associations between the variables under study in all participants, similar to the findings of the present study. Our present study adds to our previous investigation by including a positive affect measure as well as by studying a large sample from the general population. Our results are also in accordance with Baer and colleagues (2012), who found that improvements in mindfulness in the first weeks of MBSR predicted subsequent change in weekly measures of stress. We extend this finding by using more fine-grained and bidirectional analyses of daily within-person changes and by studying inter-individual differences.

The present study had a number of strengths. We used an intensive
longitudinal design to study the temporal order of change. This design overcomes limitations of previous studies as it allows making inferences on the temporal order of the dynamic processes that take place within individuals. Also, we presented detailed information on individual differences in the within-person dynamic associations. Several limitations should be mentioned as well. First, the variables were assessed only once a day and shorter measurement intervals may have yielded different results. Therefore, we cannot rule out that some effects were already established during the day or that there were positive feedback loops between mindfulness and affect during the day. Future studies may use more intensive sampling schedules to examine which time interval matches the speed of the effect of mindfulness on affect. Furthermore, the use of only 10 daily mindfulness and affect items might limit the validity of the measures, although our measures correlated highly with the original total scores.

In conclusion, our results make a reasonable case that increases in mindfulness precede improvements in negative affect and positive affect, instead of increases in mindfulness being a side-effect of an improved mood. The results correspond with the rationale of mindfulness-based interventions; training mindfulness skills may indeed be a beneficial means to improve psychological wellbeing. The findings of the study could be valuable beyond the context of MBSR as individuals may also improve their daily psychological wellbeing by practicing mindfulness in their daily life. Yet, one should bear in mind that the temporal association between mindfulness and affect seems to be stronger for some individuals than for others. Future research could examine factors that may predict the individual differences in the association between mindfulness and affect.
Part 2

The role of patients’ perceptions in CBT and MBCT for depressive symptoms in patients with diabetes