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Mindfulness training increases momentary positive emotions and reward experience in adults vulnerable to depression. A randomized controlled trial.

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Abstract

Objective: To examine whether Mindfulness-Based Cognitive Therapy (MBCT) increases momentary positive emotions and the ability to make use of natural rewards in daily life.

Method: Adults with a life-time history of depression and current residual depressive symptoms (mean age 43.9 years, *SD* 9.6; 75 % female; all Caucasian) were randomized to MBCT (n = 64) or waitlist control (CONTROL; n = 66) in a parallel, open-label, randomized controlled trial. The Experience Sampling Method was used to measure momentary positive emotions as well as appraisal of pleasant activities in daily life during six days before and after the intervention. Residual depressive symptoms were measured using the 17-item Hamilton Depression Rating Scale.

Results: MBCT compared to CONTROL was associated with significant increases in appraisals of positive emotion (b* = .39) and activity pleasantness (b* =.22), as well as enhanced ability to boost momentary positive emotions by engaging in pleasant activities (b* =.08; all p < .005). Associations remained significant when corrected for reductions in depressive symptoms, or for reductions in negative emotion, rumination and worry. In the MBCT condition, increases in positive emotion variables were associated with reduction of residual depressive symptoms (all p < .05).

Conclusions: MBCT is associated with increased experience of momentary positive emotions, greater appreciation of, and enhanced responsiveness to pleasant daily-life activities. These changes were unlikely to be pure epiphenomena of decreased depression and, given the role of positive emotions in resilience against depression, may contribute to the protective effects of MBCT against depressive relapse.

Keywords: MBCT, Mindfulness-Based Cognitive Therapy, residual symptoms, positive affect, Ecological Momentary Assessment

Major depression is a common and highly recurrent clinical condition – an estimated 75 to 90 percent of patients will have multiple episodes (e.g., Mueller, et al., 1999). Even after different treatment steps a considerable number of depressed participants continue to experience residual symptoms of depression (Rush, et al., 2006). Residual symptoms not only impact negatively on quality of life, they are also associated with three times faster relapse, compared to full recovery (Judd, et al., 1998; Rush, et al., 2006). Residual symptoms commonly include sleep disturbances, loss of energy, and decreased pleasure, motivation and interest. Overall, this pattern of symptoms is consistent with lower levels of positive affect (Nutt, et al., 2007; Watson, Clark, & Carey, 1988) - a core symptom of Major Depressive Disorder. Previous studies suggest that positive affect promotes prevention of and recovery from depression (Geschwind, Nicolson, Peeters, Van Os, & Wichers, 2010a; Morris, Bylsma, & Rottenberg, 2009; Wichers, et al., 2010). Prevention efforts focused on increases in positive affect are therefore likely to (a) improve residual symptoms and well-being, and (b) prevent relapse.

Positive Affect, Well-being, and Depression

Experiencing positive emotions and having a positive attitude have beneficial effects on mental and physical health in general (Seligman, Steen, & Peterson, 2005). A meta-analysis of cross-sectional, longitudinal and experimental studies demonstrated that positive affect was associated with and preceded success, indicating that positive affect facilitates accomplishment (Lyubomirsky, King, & Diener, 2005). Evidence also suggests that positive affect is a source of resilience against pain and negative affectivity. For example, in a study in which women with chronic pain were interviewed weekly, higher levels of positive affect predicted lower levels of pain in subsequent weeks. Higher weekly levels of positive affect also resulted in lower levels of negative affect both directly and in interaction with stress and pain (Zautra, Johnson, & Davis, 2005). A recent study suggests that especially in-the-moment

positive emotions, rather than more general satisfaction with life, are associated with increased resilience (Cohn, Fredrickson, Brown, Mikels, & Conway, 2009). Momentary assessment studies, in which experiences are sampled repeatedly at random moments in daily life, support this view. For example, high daily life reward experience (i.e., the ability to generate positive affect from pleasant daily events) predicted increased resilience against later affective symptoms in participants vulnerable to depression (Geschwind, et al., 2010b; Wichers, et al., 2010). Furthermore, in participants with a lifetime history of depression, scoring one standard deviation higher on the ability to generate positive affect from pleasant daily life events was associated with a three-fold reduction in risk to experience a future episode (Wichers, et al., 2010).

Studies show that depressed participants, compared to never-depressed controls, experience less positive affect in the course of daily life (Barge-Schaapveld, Nicolson, Berkhof, & deVries, 1999; Bylsma, Taylor-Clift, & Rottenberg, 2011; Peeters, Berkhof, Delespaul, Rottenberg, & Nicolson, 2006). Also, they generate less positive affect from pleasant stimuli during experimental tasks (Bylsma, Morris, & Rottenberg, 2008), though in daily life this phenomenon is debatable (Bylsma, et al., 2011; Peeters, Nicolson, Berkhof, Delespaul, & De Vries, 2003).

Taken together, the evidence suggests that (a) high levels of positive affect have beneficial effects on vulnerability to, prevention of, and recovery from depression, and that (b) depressed individuals generate less positive affect, compared to non-depressed individuals. In other words, positive affect may represent a resilience phenotype against depression. Individuals vulnerable to depression may therefore benefit from learning to experience more positive affect. The question arises how people can reshape emotional processes in a way that heightens their ability to experience positive affect in their daily lives. One momentary assessment study showed that response to a six-week treatment with

antidepressant medication was associated with a heightened ability to boost positive affect through pleasant activities, relative to baseline (Wichers, et al., 2009). However, advocating use of antidepressant medication for prevention purposes only is problematic - and whether a behavioral, non-pharmacological, intervention can be used to heighten participants' ability to generate positive emotions in daily life has never been tested.

An intervention currently receiving empirical support for the prevention of depressive relapse and recurrence, and for the treatment of residual depressive symptoms, is Mindfulness-Based Cognitive Therapy (MBCT; Segal, Williams, & Teasdale, 2002). Although many authors assume changes in cognitive processes to be a core element of the beneficial effects of MBCT (Segal, et al., 2002), it is unclear if and how MBCT affects alterations in emotional experiences. As we argue below, there is reason to believe that MBCT may have the potential to induce changes in resilience phenotypes associated with positive affect.

Mindfulness-Based Cognitive Therapy

During mindfulness exercises, participants attempt to maintain attention on a particular focus, for example their own breathing. Whenever the attention wanders away from breathing to thoughts or feelings, participants are encouraged to acknowledge and accept these thoughts and feelings but then let go of them and direct their attention back to breathing. Participants then use the same approach in the course of daily life: they aim to focus on the 'here and now' (to engage with the present experience) and to redirect their attention whenever they notice that it has switched to distracting thoughts and worries. Next to this attentional aspect, mindfulness also works on an attitudinal dimension by promoting the cultivation of an open, curious and mild orientation of mind. The essence of a mindful state is to be fully in the present moment, to experience the present moment without judgment or evaluation and without worrying about the future or ruminating about past experiences (Kabat-Zinn, 1990).

Mindfulness-Based Cognitive Therapy (MBCT) is specifically designed to prevent depressive relapse and recurrence. MBCT combines methods of meditation and mindfulness training (Kabat-Zinn, 1990) with features of cognitive therapy for depression (Beck, Rush, Shaw, & Emergy, 1979; Teasdale, Segal, & Williams, 1995). The original idea behind MBCT was to train participants to disengage from automatic negative thinking patterns that arise during dysphoric mood and facilitate relapse (Teasdale, et al., 2000). Several studies have shown that MBCT is associated with reduced depressive symptoms and lower risk of relapse (Bondolfi, et al., 2010; Kuyken, et al., 2008; Ma & Teasdale, 2004; Teasdale, et al., 2000). Furthermore, recent studies found that MBCT is associated with reduced cognitive reactivity (Kuyken, et al., 2010; Raes, Dewulf, Van Heeringen, & Williams, 2009), rumination (Williams, 2008), and worry (Evans, et al., 2008).

However, there is reason to believe that MBCT might also increase participants' capacity for the experience of positive affect (Geschwind et al., 2010b; see also Garland, et al., 2010). Studies show that more advanced meditators experience more positive emotions (Easterlin & Cardena, 1998), and that people report more positive emotions when in a mindful compared to a non-mindful state (Brown & Ryan, 2003; Killingsworth & Gilbert, 2010). Furthermore, in a randomized controlled trial, participants of loving-kindness meditation (LKM) reported stronger increases in positive affect over time, compared to control participants (Fredrickson, Cohn, Coffey, Pek, & Finkel, 2008). During LKM participants practice to experience love and compassion first towards themselves and then towards loved ones, acquaintances, and strangers (Fredrickson et al., 2008). This very explicit focus on positive emotions may, however, create a demand bias, which is much less pronounced in MBCT. Although awareness of pleasant events and nourishing activities is addressed during two to three of the eight training sessions (just as reactions to stressful situations are dealt with), the main focus during MBCT sessions is to develop an increased

moment-to-moment awareness of experience (Baer, 2003). As pleasant events and emotions are usually less enduring, intense and attention-grabbing than unpleasant events and emotions (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001), they may be more easily overlooked than their unpleasant counterparts. Increased moment-to-moment awareness, achieved in a mindful state, may help people to perceive fleeting pleasant events or emotions and to generate more enjoyment from pleasant activities (Schroevers & Brandsma, 2010).

Hypotheses

Positive affect is associated with increased resilience against depression, but it remains unclear to which extent phenotypes related to positive affect can be modified trough behavioral interventions. We propose that MBCT is an intervention that increases the ability to make use of natural, moment-to-moment rewards in the environment, thereby increasing positive affect. Our primary hypothesis is that, after MBCT, participants (a) experience more positive affect, (b) rate pleasant daily-life activities as more pleasant, and (c) experience more reward (i.e., generate more positive affect from engaging in pleasant activities). Because previous literature has shown that MBCT is associated with decreased worry, rumination (see above) and negative affect (Schroevers & Brandsma, 2010), we will additionally examine to which extent potential changes in positive affect, pleasant activities, and reward experience are independent of decreases in worry, rumination and negative affect. Because of the protective links between positive affect and depression, a secondary hypothesis is that increases in positive affect, pleasant activities, and reward experience will be associated with decreases in depressive symptoms within the MBCT condition.

Hypotheses were tested in an open-label, parallel, randomized controlled trial comparing participants who continued with treatment as usual to participants who, additionally, received MBCT. To measure the fleeting momentary experience of positive emotions (Garland, et al., 2010) in an ecologically valid and reliable manner, the Experience

Sampling Method (ESM) was used. ESM is a momentary assessment technique in which participants are prompted to report on their current experiences at random moments during the day. ESM is therefore ideally suited to investigate changes in people's emotional reactions to their daily environment (Csikszentmihalyi & Larson, 1987). To our knowledge, this is the first study to examine how MBCT is associated with changes in people's momentary affective responses in their daily life context. Furthermore, this trial is the first to examine whether a non-pharmacological intervention can be used to modify a resilience phenotype (the ability to experience and generate positive emotions in daily life) in a sample vulnerable to depression.

Method

Participant Characteristics

For the current study (acronym MindMaastricht; trial number NTR1084, Netherlands Trial Register), adults with residual symptomatology after at least one episode of Major Depressive Disorder were recruited from outpatient mental health care facilities in Maastricht and through posters in public spaces. Residual symptoms are associated with higher risk of relapse (Judd et al., 1998) and were therefore required as an indicator of vulnerability to depression. Residual symptoms were defined as a score of seven or higher on the 17-item Hamilton Depression Rating Scale (HDRS; Hamilton, 1960) at the time of screening. Exclusion criteria were: fulfilling criteria for a current depressive episode, schizophrenia, psychotic episodes in the past year, and recent (past four weeks) or upcoming changes in ongoing psychological or pharmacological treatment. Currently depressed individuals were excluded because, at trial preparation, there was no evidence that currently depressed individuals were able to participate in or benefit from MBCT. Relevant sociodemographic and clinical characteristics are displayed in table 1.

Sampling procedures

All study procedures were approved by the Medical Ethics Committee of Maastricht University Medical Centre, and all participants signed an informed consent form. An initial screening of potential participants for this randomized controlled trial was performed by phone to check for availability during the study period and likelihood of meeting in- and exclusion criteria. A second screening included administration of the Structured Clinical Interview for DSM IV axis I (SCID-I; First, Spitzer, Gibbon, & Williams, 2002) and the 17-item HDRS by trained psychologists. Eligible participants were invited for a detailed one-on-one explanation of the experience sampling procedure, and then took part in the baseline assessment. The baseline assessment consisted of six days of experience sampling in their own environment (see section Experience Sampling Method; ESM), and subsequent administration of a battery of questionnaires (see section Measures) as well as the HDRS interview (in the laboratory). After the baseline assessment, participants were randomized to either MBCT or waiting list (CONTROL; allocation ratio 1:1) if they were likely to have at least 20 valid ESM assessments (Delespaul, 1995; see Experience Sampling Method). After either eight weeks of MBCT (see section "Intervention") or equivalent waiting time (in the CONTROL condition), participants again took part in six days of experience sampling, followed by the administration of the HDRS and the questionnaires. All participants were compensated with gift vouchers worth 50 Euros. Participants in the CONTROL condition had the opportunity to take part in MBCT after the post-intervention assessment.

Randomization to treatment condition was stratified according to number of depressive episodes (two or less versus three or more), as previous studies suggest a greater benefit for those with three or more previous episodes (Ma & Teasdale, 2004; Teasdale, et al., 2000). An independent researcher not involved in the project generated the randomization sequence in blocks of five (using the sequence generator on www.random.org), and wrote the randomization code into sealed numbered envelopes. After completion of all baseline

assessments, the researcher allocated participants to their treatment condition based on the randomization code in the sealed envelope (opened in order of sequence). No masking of treatment condition took place.

Sample Size and Power

Sample size ($n \geq 120$) was determined on the basis of sufficient power for gene-environment interactions (not analyzed here). Post-hoc power calculations for the current analyses (using Stata 11s SAMPSI command; StataCorp, 2009) indicated a power of $> .90$ to detect small effects ($d = 0.2$) in the parameter of interest, the group*time interaction.

Intervention (MBCT)

Content of MBCT training sessions followed the protocol of Segal, Williams, and Teasdale (2002). Trainings consisted of eight weekly meetings lasting 2.5 hours and were run in groups of 10-15 participants (thus occasionally larger than the usual 10-12 participants per group). Assessment periods for control participants were matched to those of MBCT participants. Sessions included guided meditation, experiential exercises, and discussions. In addition to the weekly group sessions, participants received CDs with guided exercises and were assigned daily homework exercises (30 to 60 minutes daily). Trainings were given by experienced trainers in a centre specialized in mindfulness trainings. All trainers were supervised by an experienced health care professional who had trained with Teasdale and Williams, the co-developers of MBCT (Teasdale, et al., 1995).

Experience Sampling Method

ESM is a momentary assessment method to assess participants in their daily living environment, thus providing repeated in-the-moment assessments of affect in a prospective and ecologically valid manner (Csikszentmihalyi & Larson, 1987; Peeters, et al., 2003). Compared to retrospective questionnaires and interviews, ESM offers several advantages: (a) enhanced ecological validity, because participants are assessed in their normal daily

environments, (b) minimized retrospective bias, because participants' experiences are assessed in the moment, and (c) enhanced reliability, because participants' experiences are assessed repeatedly (Csikszentmihalyi & Larson, 1987).

In the current study, participants received a digital wristwatch and a set of ESM self-assessment forms collated in a booklet for each day. The wristwatch was programmed to emit a signal ("beep") at an unpredictable moment in each of ten 90-minute time blocks between 7:30 am and 10:30 pm, on six consecutive days, resulting in a maximum of 60 beeps per study period. After each beep, participants were asked to fill out the ESM self-assessment forms previously handed to them, collecting reports of current mood and context. All self-assessments were rated on 7-point Likert scales. Trained research assistants explained the ESM procedure to the participants during an initial briefing session, and a practice form was completed to confirm that participants understood the 7-point Likert scale. Participants were instructed to complete their reports immediately after the beep, thus minimizing memory distortion, and to record the time at which they completed the form. All reports not filled in within 15 min after the actual beep were excluded from the analysis, since previous work (Delespaul, 1995) has shown that reports completed after this interval are less reliable and consequently less valid. For the same reason, participants with less than 20 valid reports at baseline were excluded from the analysis (Delespaul, 1995).

Measures

Pleasantness of daily life activities. To define pleasantness of daily life activities in an ecologically valid manner, ESM self-rated appraisals of ongoing activities were used, consistent with several previous studies of emotional reactivity to appraised daily activities and contexts (Myin-Germeys & van Os, 2007; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001; Wichers, et al., 2009). Participants rated their current activity on a 7-point Likert scale (with 1 = not at all and 7 = very). Factor analysis supported inclusion of four

items for activity appraisal (with factor loadings > .6), namely: *I enjoy this activity*, *This activity requires effort*, *I would prefer to do something else* and *I am skilled at doing this activity*. Two items (*I feel I'm being active* and *This is a challenge*) had low factor loadings (.05 and .12, respectively), and were consequently not included in the activity pleasantness score. On the basis of the included ratings, a variable reflecting 'pleasantness of current activity' was generated. Before creating the activity pleasantness variable, the items 'This activity requires effort' and 'I would prefer to do something else' were first recoded so that high scores reflected lower appraised effort and higher preference for the current activity. Consistent with Wichers and colleagues (2009), low scores (≤ 4) on all four items were set to zero (so that negative activity appraisals did not contribute to the overall score), and higher scores were recoded (5=1, 6=2, 7=3) before calculating a sum score for activity pleasantness. High pleasantness thus reflected high skill, low effort, low preference for doing something else, and high enjoyment of the activity.

Positive affect (PA) and negative affect (NA). At each beep, several ESM mood adjectives were assessed on 7-point Likert scales ranging from 1 (not at all) to 7 (very). Consistent with previous work (Myin-Germeys, et al., 2001; Wichers, et al., 2010), principal component factor analysis with oblique rotation was used to generate a factor representing positive affect (PA) and a factor representing negative affect (NA). The mood adjectives *happy, satisfied, strong, enthusiastic, curious, animated* and *inspired* loaded on the PA factor (alpha = .89), while *down, anxious, lonely, suspicious, disappointed, insecure* and *guilty* loaded on the NA factor (alpha = 0.86). One mood item (*I feel relaxed*) was not included in the PA factor due to low factor loadings (< .6). Mean levels of PA and NA were then computed per participant and beep moment.

Reward experience. Reward experience was conceptualized as the effect (the standardized coefficient *b**) of pleasant activities on momentary PA. This coefficient captures

the increase in PA when engaging in pleasant activities, relative to baseline. Reward experience thus was not a precalculated variable but hidden in the outcome of the analyses (consistent with Wichers, et al., 2009), so there was no way in which participants could consciously fake the outcome on this variable.

Hamilton Depression Rating Scale (HDRS). The 17-item HDRS was administered by two trained research assistants with Master degrees in Psychology. The HDRS (Hamilton, 1960) is a semi-structured interview designed to assess depressive symptoms over the past week. It is one of the most often used rating scales in depression research, and internal, interrater, and retest reliability estimates for the overall HDRS are good (Bagby, Ryder, Schuller, & Marshall, 2004). Only the overall score was used for the analyses, and interrater reliability for the total score was high (IntraClass Correlation coefficient = .97). To provide information on interrater reliability, both interviewers had independently rated eight video-taped HDRS interviews with patients varying in strength of residual depressive symptoms.

Inventory of Depressive Symptoms (Self-Rating; IDS-SR). The IDS-SR (Rush, Gullion, Basco, Jarrett, & Trivedi, 1996) is a self-rated scale, which includes 30 items rated on a scale from 0 to 3. Since rating of 'appetite' and 'weight' is duplicated (separate items for increases and decreases), only 28 items are taken into account for the final score. The scale is sensitive to change and has good psychometric properties (Rush, et al., 1996). Internal consistency in the current sample was .85.

Penn State Worry Questionnaire (PSWQ). A Dutch version of the 16-item PSWQ was used to assess worrying. The PSWQ emerged from factor analysis of a large number of items and was found to possess high internal consistency and good test-retest reliability (Meyer, Miller, Metzger, & Borkovec, 1990). Internal consistency in our sample was .90.

Rumination on Sadness Scale (RSS). The approved Dutch back-translation (Raes, Hermans, & Eelen, 2003) of the RSS (Conway, Csank, Holm, & Blake, 2000) was used to

measure rumination. The RSS contains 13 items comprising one factor, has an adequate test–retest stability over a 2- to 3-week period, and has good convergent and discriminant validity (Conway, et al., 2000). Internal consistency in the current sample was .90, similar to earlier studies (e.g., Conway, et al., 2000).

Statistical Methods

Experience Sampling Method data have a hierarchical structure. Thus, multiple observations (level 1) are clustered within participants (level 2). Multilevel analyses take the variability associated with each level of nesting into account (Snijders & Bosker, 1999). Multilevel linear regression analyses, using the XTREG command in STATA 11.1 (StataCorp, 2009) were applied to the ESM data. 'Reward Experience' was conceptualized as the effect of positively appraised daily life activities on PA (i.e., the boost in PA when participants engage in more pleasant compared to neutral activities).

First, we examined the effects of MBCT on change in positive affect, pleasantness of activities, and reward experience, relative to CONTROL. Thus, in the models of PA and activity pleasantness, the two-way interaction between time (baseline vs. post assessment) and treatment group (CONTROL vs. MBCT) was the parameter of interest. For reward experience, the three-way interaction between time (baseline vs. post assessment), treatment group (CONTROL vs. MBCT), and activity pleasantness in the model of PA was the parameter of interest. The MARGINS, DYDX command (StataCorp, 2009) was used to calculate the effect of activity pleasantness on PA in the four different conditions (MBCT and CONTROL, at baseline and post-intervention). Per treatment group, significance of differences between baseline and post-assessment were then assessed with Stata's TEST command, which uses the Wald test (Clayton & Hill, 1993). To refute concerns that improvements in PA-related variables may simply reflect epiphenomena of decreased depression scores, analyses were reran post-hoc whilst correcting for reduction on the HDRS.

Second, to examine to what extent the effect of treatment on PA, pleasant activities, and reward experience was independent of changes in third variables known from MBCT research, the above-mentioned analyses were repeated whilst including the interaction terms containing changes in worry, rumination, and NA (i.e., time*worry + time*rumination + time*NA).

Third, we examined to what extent MBCT-related improvements in the variables PA, activity pleasantness, and reward experience were associated with decreases in depressive symptoms. For this reason, analyses for all three variables were repeated in the MBCT group only, using "Reduction on the HDRS" (baseline minus post assessment) in the interaction terms instead of treatment group. To visualize these associations more clearly, and to examine dose-response associations between improvements in PA-related variables and depressive symptoms, we then divided improvement on the HDRS into tertiles. The strength of associations was tested using the margins command, and significance was assessed using the Wald test (Clayton & Hill, 1993). To ensure that these associations were independent of the format of measurement, the analyses were repeated using the self-report IDS-SR to classify change in depressive symptoms (instead of the clinician-rated HDRS).

Because average levels at baseline naturally influence the extent to which a variable can increase (e.g., ceiling effects), the analyses on PA and reward experience were corrected for individually averaged baseline levels of PA. Similarly, the analyses on activity pleasantness were corrected for averaged baseline ratings of activity pleasantness.

The reported analyses are based on the whole sample (intention to treat). Participants who attended less than four MBCT sessions (n = 3) were excluded for the per-protocol analysis (outcomes were similar and are not reported in detail).

Results

Participants

Recruitment of participants started in January 2008 and ended in February 2009, and all post-intervention assessments were completed by August 2009, when the pre-determined number of participants was reached. Sociodemographic and clinical characteristics of MBCT and CONTROL participants are displayed in Table 1. At baseline, there were no large or significant differences between treatment groups with respect to sociodemographic and clinical characteristics. Table 2 shows baseline and post assessment scores of variables used in the analyses, stratified by treatment group. Again, there were no large or significant differences between groups at baseline. Participant flow through the study is displayed in Figure 1. No known harms or unintended treatment effects were reported in either group.

Participants completed 12,453 entries in total. Of these, 559 (4 %) were excluded as invalid entries, because completion times fell outside the pre-determined window of 15 minutes after the beep. On average, participants completed 49 (of 60; *SD* = 7.6) valid entries per assessment period. One participant had completed fewer than 20 valid entries at baseline and was therefore excluded from the analyses.

Effects of MBCT on PA-related variables

MBCT compared to CONTROL was associated with significant increases in PA, $b^* = .40$, 95 % CI [.33, .46], $\chi^2(1) = 163.02$, $p < .001$. Similarly, MBCT was associated with increases in activity pleasantness, compared to CONTROL, $b^* = .22$, 95 % CI [.15, .29], $\chi^2(1) = 39.09$, $p < .001$. Also reward experience increased significantly in the MBCT group, compared to CONTROL, $b^* = .08$, 95 % CI [.03, .14], $\chi^2(1) = 8.23$, $p = .004$. Standardized predicted values of PA-related variables, by group and assessment period, are displayed in Figure 2. Effects of treatment condition on PA-related variables were similar when the analyses were repeated whilst correcting for change in residual depressive symptoms (b^* = .40, .22, and .08 for PA, activity pleasantness, and reward experience, respectively),

indicating that the effects of MBCT on PA-related variables were not just epiphenomena of reduction in depressive symptoms.

Independence of effects of MBCT on PA-related variables

As can be seen in Table 2, MBCT was also associated with significant reductions in worry, rumination, and NA, compared to CONTROL. However, effects of MBCT on PA-related variables were reduced but remained evident and statistically significant when changes in worry, rumination, and NA were included in the analyses. The effect size of the time (baseline vs. post-assessment) by group (MBCT vs. CONTROL) interaction term then became $b^* = .19$, $p < .001$ (unadjusted $b^* = .40$) in the model of PA, and $b^* = .16$, $p < .001$ (unadjusted $b^* = .22$) in the model of activity pleasantness. In the model of reward experience the effect size of the three-way interaction term time*group*activity pleasantness became $b^* = .07$, $p = .007$ (unadjusted $b^* = .08$).

Clinical Significance: Association between symptom reduction and PA-related increases

With regard to clinical significance, analyses restricted to the MBCT group showed that reduction on the HDRS was associated with significant increases in PA, $b^* = .30$, 95 % CI [.26, .34], $p = .000$, activity pleasantness, $b^* = .05$, 95 % CI [.002, .10], $p = .000$, and reward experience, $b^* = .06$, 95 % CI [.02, .09], $p = .003$.[1] In order to examine dose-response relationships, participants were classified as low ($n = 21$, mean reduction in HDRS scores $\Delta M = -1.94$, $SD = 2.83$, range -9 to 1), medium ($n = 22$, HDRS $\Delta M = 3.89$, $SD = 1.02$, range 2 - 5), and high responders ($n = 20$, HDRS $\Delta M = 8.31$, $SD = 1.53$, range 6 - 12) to MBCT, using a tertile split. Figure 3 displays standardized predicted values of PA-related variables by

[1] For the per-protocol analyses (thus excluding the three participants who attended less than four MBCT sessions) results were similar to those reported above, except for one of the secondary outcomes, the association between reduction of residual symptoms and activity pleasantness. This association became nonsignificant, $p = 0.217$, $b^* = .03$, 95 % CI [-.02, .08].

tertiles of response and assessment period (pre vs. post MBCT), confirming the predicted pattern of results. Results were similar when the IDS-SR was used to assess symptom reduction instead of the HDRS.

Discussion

Current findings

Effects of Mindfulness-Based Cognitive Therapy (MBCT) were compared to a waitlist control condition (CONTROL) in adults with a history of major depression and current residual symptoms. Overall, our results support the primary hypothesis that MBCT is associated with both enhanced experience of pleasant daily-life situations and improved positive affect (PA) responsiveness to pleasant daily-life situations. Results showed that MBCT was associated with (a) more overall PA, (b) higher appraisal of activities as pleasant, and (c) higher levels of reward experience, compared to baseline, and compared to CONTROL. Special attention was given to the question whether PA-related changes after MBCT may have simply been epiphenomena of reduced depression. The effects of treatment condition remained similar in analyses additionally correcting for reduction of depressive symptoms, indicating that MBCT affected changes in PA-related variables independent of degree of improvement in depressive symptomatology. Further analyses examined to which extent effects of MBCT on PA related variables were independent of changes in worry, rumination (variables on which MBCT research has focused so far), and negative affect. Effect sizes of MBCT on PA-related variables were reduced but remained significant when changes in worrying, rumination, and negative affect were included.

In line with our secondary hypothesis, increases in positive affect variables within the MBCT group were associated with reductions in residual depressive symptoms, indicating the potential relevance of increased positive affect for the prevention of depression. There was a dose-response relation between reductions on the clinician-rated Hamilton Depression

Rating Scale (HDRS) and the PA-related variables. MBCT participants with the highest reduction in residual symptoms (based on a tertile split of the distribution) experienced significantly stronger increases in PA, activity pleasantness, and reward experience than those with medium improvement, who in turn experienced stronger increases that those in the low improvement group (except for activity pleasantness and reward experience, where only the high improvement group differed from the other two groups).

The other face of MBCT: changing the experience of positive emotions

Our findings suggest that modification of a resilience phenotype (more frequent experience of daily-life PA, as well as enhanced PA responsiveness to pleasant daily-life activities) is possible. Increases in PA, activity appraisal, and reward experience were specific to MBCT (with no significant increases in the control condition), and partially independent of more commonly observed decreases in worry, rumination and negative affect (Raes, et al., 2009; Teasdale, et al., 1995; Teasdale, et al., 2000). This points to the possibility that MBCT may directly facilitate the experience of positive emotions, as suggested by Garland and colleagues (2010). For example, enhanced engagement with the present experience (one of the main goals of MBCT) is associated with broadening of attention (Lutz, Slagter, Dunne, & Davidson, 2008), and may therefore lead to higher awareness of pleasant situations (which are more easily overlooked than unpleasant situations; Baumeister, et al., 2001). This higher awareness of pleasant situations, in combination with the curious and mild attitude taught during MBCT, may in turn lead to increases in individuals' hedonic capacity (Schroevers & Brandsma, 2010).

Although the current study provides initial support for the assumption that MBCT may increase the experience of reward and positive emotions (phenotypes that have been associated with better resilience against depressive symptomatology), future research should examine whether or not the experimental modification of reward experience represents a

mechanism of change of MBCT. Kazdin (2007) provides a compelling account about how research on mindfulness mechanisms may best progress. For example, an association between the extent of the experimental increase in reward experience and a more favorable future course of illness would support the hypothesis of reward experience as a mechanism of change of MBCT. Studies might also investigate whether increased engagement with the present experience (as proposed above), or rather changes in third variables drive greater appreciation of, and enhanced responsiveness to pleasant activities. Furthermore, without an active treatment comparison it is impossible to know whether the changes in PA are specifically due to increased mindfulness. Therefore, future studies investigating associations between MBCT and change in PA should include a third attention-control arm (or alternatively a 'pure' arm, in which nourishing or rewarding activities are not at all addressed during the intervention). Finally, research investigating whether certain individual differences or clinical characteristics determine individual variation in the primary changes after MBCT would also be valuable. For example, some participants may benefit from MBCT mainly through reduction of worrying, while others may benefit mainly through changes in the experience of positive emotions.

Clinical Implications

A growing body of literature indicates that the efficient generation of positive emotions may be a resilience phenotype: PA is very important for well-being in general (Folkman & Moskowitz, 2000; Seligman, et al., 2005) and the prevention of and recovery from depression in particular (Garland, et al., 2010; Wichers, et al., 2009). Several studies suggest that it would be clinically relevant to change the ability to experience of PA if that were possible. High levels of reward experience have been shown to protect against the development of affective symptoms (Geschwind, et al., 2010b; Wichers, et al., 2010), and were associated with recovery from depression after pharmacotherapy (Wichers, et al., 2009)

in other, unrelated samples. The present study, to our knowledge, is the first to show that a behavioral, non-pharmacological intervention is associated with enhanced generation of PA during pleasant daily-life activities. However, due to the lack of an active intervention group, we cannot assume causality. An alternative explanation for our findings is that decreases in depressive symptoms could lead to increases in positive affect.

Despite statistical significance, the clinical significance may seem less obvious, because increases in PA are relatively small (e.g., PA increased from 3.7 to 4.2 on a 7-point Likert scale in the MBCT condition). On the other hand, a previous study showed that very small increases in PA can be strong predictors of clinically relevant change. For example, small improvements in daily-life PA (from 3.3 to 3.6 on a 7-point Likert scale) during the first week of antidepressant treatment were associated with a 34 times higher chance on achieving remission six weeks later, compared to no change or worsening of PA during the first week (Geschwind et al, 2010a).

Another clinically relevant finding is that increased reward experience following MBCT co-occurred with the reduction of residual complaints (which are harmful and increase the risk for future episodes of major depression; Judd, et al., 1998). Effects of MBCT on PA-related variables did not change when corrected for change in residual depressive symptoms, indicating that PA-related improvements were not simply epiphenomena of reductions in depressive symptoms. To verify this claim more definitely, however, replication of results in a symptom-free sample is desirable. Furthermore, future studies should look beyond changes in traditionally researched MBCT outcome variables and investigate to what extent MBCT-induced changes in positive emotionality and other resilience-related constructs contribute to recovery from depression and relapse prevention.

Strengths and limitations

Strengths of the current study include the use of the Experience Sampling Method (ESM) to measure changes in positive affectivity. ESM repeatedly measures positive emotions as they occur in daily life, thus increasing ecological validity and minimizing memory bias (Csikszentmihalyi & Larson, 1987). Although ESM relies on self-report, demand bias for the main outcome (change in PA-related variables) was unlikely for the following reasons: (i) positive affect items were hidden among other items describing the current activity and situation, and participants were blind to the hypotheses; (ii) MBCT's main focus is to encourage participants to engage with the present moment (although MBCT does also address nourishing activities), and (iii) most previous research has focused on negative emotions, rumination, or worry. Another strength of the current study is that inclusion criteria were intentionally kept at a low threshold in order to enhance generalizability. Moreover, attrition rate was low, and the main analyses focused on the intention-to-treat sample, thus analyzing all participants randomized to treatment. Finally, the study was a randomized controlled trial, thus reducing selection bias, and there were no prior differences in baseline or clinical characteristics between MBCT and CONTROL.

Limitations are (a) that the current trial did not include an active control intervention arm, making conclusions about active treatment ingredients impossible, (b) the all-Caucasian sample, and (c) the absence of objective information on competent treatment delivery and adherence to the MBCT protocol. Another limitation is (d) the reliance on self-reported entry completion time for distinguishing valid from invalid experience sampling reports. However, an earlier study comparing self-reported completion time and objective completion time (obtained through monitoring by hidden electronic devices; Jacobs, et al., 2005) indicates that self-reported completion times are reliable. Furthermore, (e) both participants and assessors were not blind to treatment condition due to pragmatic limitations. Importantly though, participants and assessors were unaware of direction and extent of change in PA-related

variables (the main trial outcome) when assessing residual depressive symptoms. Also, associations between increases in PA-related variables and decreases in residual depressive symptoms were unlikely to be due to biased assessment, because results of self-report (IDS-SR) and interview-based (HDRS) assessment of residual depressive symptoms corresponded. A further limitation (f) is that it is impossible to say whether increase in activity appraisal indeed represents a tendency to appraise similar activities as more pleasant than before MBCT or rather a tendency to engage in more pleasant activities. However, either option has clinical relevance. The choice not to have external observers rate pleasantness of activities was made consciously, because the experience of every-day activities is entirely subjective. Moreover, this was a within-subject design and participants were compared to themselves. Finally, (g) the low-threshold inclusion criteria generate more heterogeneity between participants. However, there were no significant differences on any key variables between MBCT and CONTROL groups at baseline. Furthermore, the low-threshold inclusion criteria warrant generalizability to most individuals with residual depressive symptoms (though replication in a symptom-free sample would be desirable).

Conclusion

This is the first study to show that a behavioral intervention can lead to increased experience of momentary positive emotions, greater appreciation of, and enhanced responsiveness to pleasant daily-life activities. From a clinical point of view, this is a very relevant finding because it means that a non-pharmacological intervention may potentially improve the reward system. The clinical impact is considerable, because it makes prevention efforts targeting reward experience in vulnerable groups more acceptable.

More research is needed with regard to active treatment ingredients, mechanisms of change, and the degree to which positive emotions and other resilience-related phenotypes contribute to recovery from depression and prevention of relapse or recurrence.

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Table 1

Baseline Demographic and Clinical Characteristics per Group.

	MBCT (*n* = 63)	CONTROL (*n* = 66)
Age (*M*, *SD*)	44.6 (9.7)	43.2 (9.5)
Female gender	79 %	73 %
Full-/part-time work	62 %	68 %
Illness/unemployment benefits	19 %	23 %
Living with partner/own family	64 %	64 %
≤ 2 previous episodes of MDD	56 %	55 %
≥ 3 previous episodes of MDD	44 %	45 %
Comorbid anxiety disorder (present)	35 %	49 %
Comorbid anxiety disorder (past)	51 %	64 %
Current psycho-counseling/-therapy	13 %	12 %
Current use of antidepressants	32 %	38 %
(Occasional) use of benzodiazepines	8 %	8 %

Note. There were no significant differences between groups (at $p < .05$). MBCT = Mindfulness-Based Cognitive Therapy; CONTROL = waitlist control condition; MDD = Major Depressive Disorder.

Table 2

Means and Standard Deviations of Variables Used in the Analyses, Stratified by Group and Measurement Occasion.

	MBCT (n = 63)		CONTROL (n = 66)	
	Baseline *M* (*SD*)	Post *M* (*SD*)	Baseline *M* (*SD*)	Post *M* (*SD*)
PA	3.7 (1.3) [a]	4.2 (1.3) [b]	3.9 (1.2) [a]	3.9 (1.2) [a]
Pleasantness	2.3 (1.3) [a]	2.5 (1.3) [b]	2.3 (1.3) [a]	2.1 (1.3) [c]
HDRS	10.3 (3.7) [a]	7.1 (4.8) [b]	10.2 (3.5) [a]	9.7 (4.0) [a]
IDS-SR	22.3 (10.7) [a]	14.6 (10.7) [b]	22.5 (8.7) [a]	19.2 (9.5) [a]
RSS	42.2 (9.7) [a]	34.4 (9.8) [b]	40.8 (9.7) [a]	37.9 (10.0) [a]
PSWQ	59.7 (10.9) [a]	50.6 (11.5) [b]	59.7 (10.1) [a]	56.3 (10.3) [a]
NA	2.0 (1.1) [a]	1.6 (.8) [b]	2.0 (1.0) [a]	2.0 (1.0) [a]
MBCT sessions attended		7.2 (1.5)		
Minutes practiced per day		29.7 (13.2)		

Note. Per row, variables sharing the same subscript do not differ at $p < .05$.

MBCT = Mindfulness-Based Cognitive Therapy; CONTROL = waitlist control condition; PA = Positive Affect; Pleasantness = Appraisal of activity pleasantness; HDRS=Hamilton Depression Rating Scale; IDS-SR = Inventory of Depressive Symptoms Self-Rating; RSS = Rumination on Sadness Scale; PSWQ = Penn State Worry Questionnaire; NA = Negative Affect.

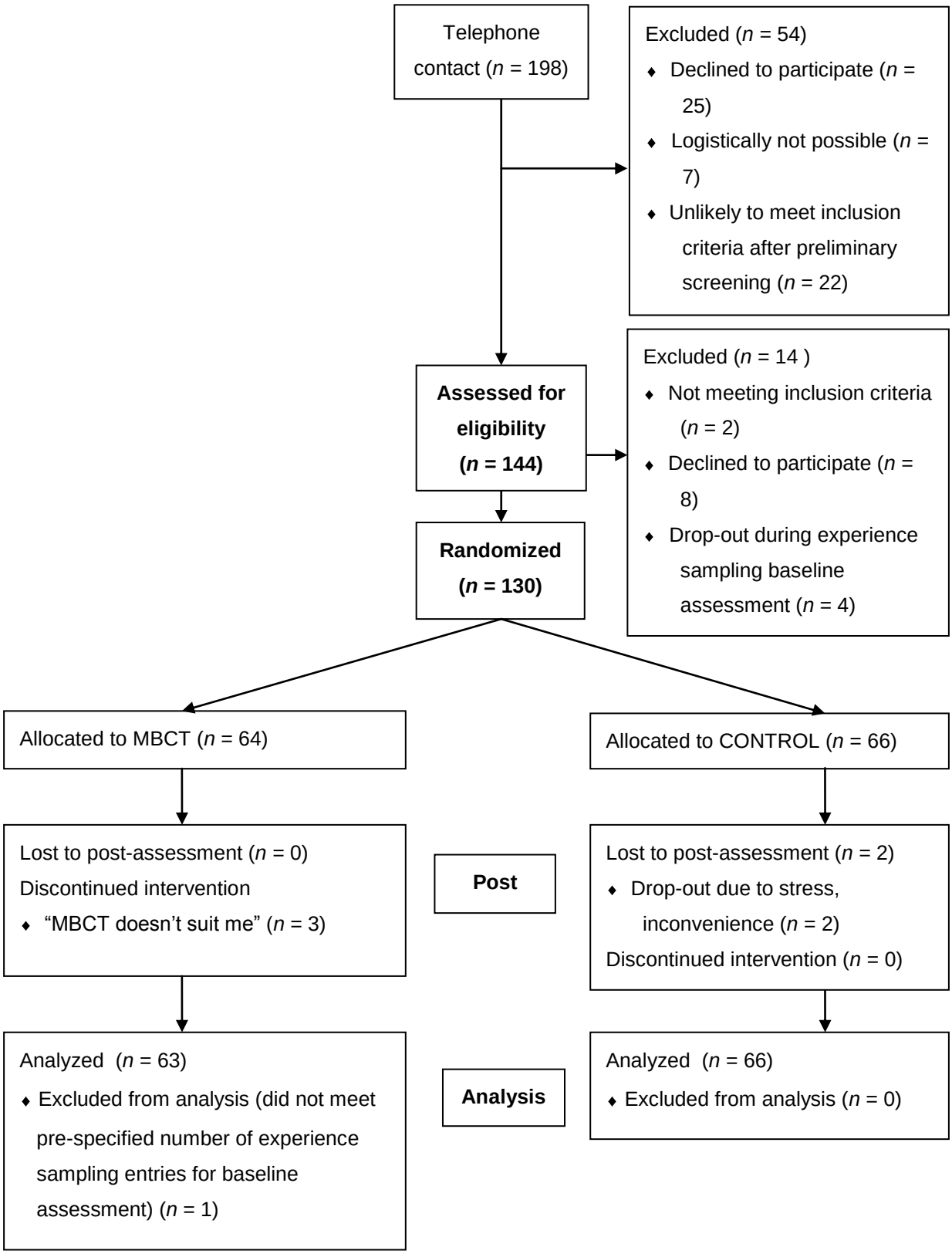

Figure 1. Participant flow diagram. MBCT = Mindfulness-Based Cognitive Therapy; CONTROL = waitlist control condition.

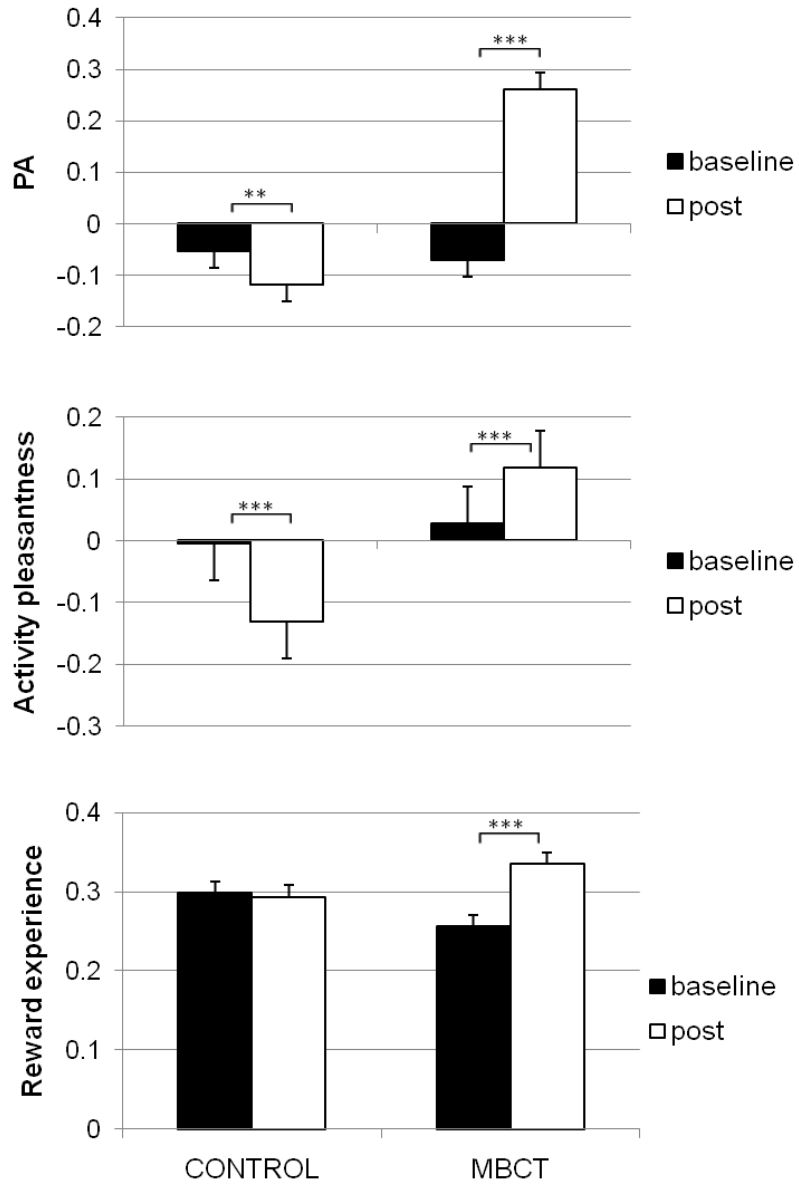

Figure 2. Standardized predicted values of positive affect, activity pleasantness, and reward experience (± *SE*) at baseline and post-assessment in CONTROL and MBCT groups. Analyses were controlled for a person's mean baseline level on the dependent variable (positive affect or activity pleasantness, respectively). MBCT = Mindfulness-Based Cognitive Therapy; CONTROL = waitlist control condition.

* $p < .05$; ** $p < .01$; *** $p < .001$

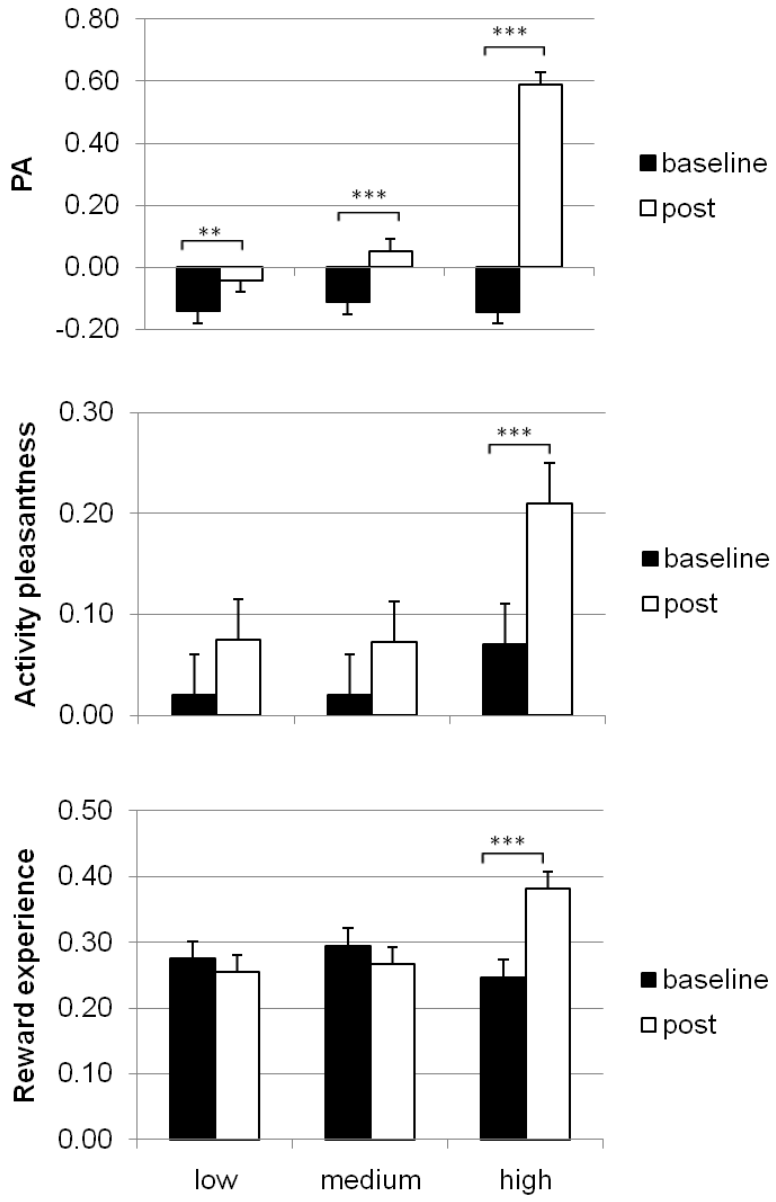

Figure 3. Association between reduction of depressive symptoms and positive affect, activity pleasantness, and reward experience, before and after MBCT. Analyses were controlled for a person's mean baseline level on the dependent variable (positive affect or activity pleasantness, respectively). Bars represent standardized predicted values (± *SE*) in low, medium, and high responders (MBCT group only). Differences between baseline and post-assessment increased with clinical response. HDRS = Hamilton Depression Rating Scale; MBCT = Mindfulness-Based Cognitive Therapy.

* $p < .05$; ** $p < .01$; *** $p < .001$

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