Associations between mindfulness and mental health outcomes: A systematic review of ecological momentary assessment research

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Abstract

Objectives: Psychological science has taken up investigations of the effectiveness of mindfulness-based programs (MBPs) and mechanisms through which people benefit from mindfulness. Reliable and valid psychometric tools are essential components of psychological science, and efforts have been made to produce tools for the accurate measurement of mindfulness as a construct. However, trait measurement methods, which are commonly used, may not adequately assess mindfulness and mental health outcomes in a way that allows for mechanisms to be adequately tested. Intensive longitudinal assessment methods sample behavior and experience multiple times over a brief period of several days or weeks, and may be more appropriate methods for testing mechanisms of action. We provide a systematic review of published, peer-reviewed studies that used intensive longitudinal methods to investigate the effects of mindfulness on mental health outcomes.

Methods: Articles were included in the systematic review if mindfulness measures and/or mindfulness interventions were a part of the study design and if intensive longitudinal methods were used to assess mindfulness or mental health outcomes.

Results: Findings consistently demonstrated a positive association between mindfulness and mental health. Only two studies collected both trait and state measurements of either mindfulness

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or mental health outcomes, and results indicated that EMA produced larger effect sizes between mindfulness and mental health outcomes.

Conclusions: Theorized associations between mindfulness and mental health are supported by the current EMA literature. Intensive longitudinal methods may produce more consistent and reliable results through increased sensitivity and ecological validity in that they examine the momentary relationships between mindfulness and mental health outcomes. Thus, intensive longitudinal assessment may be a more appropriate method for investigating hypothesized mechanisms of action in MBPs.

Keywords

Mindfulness; Mental Health Outcomes; Systematic Review; Ecological Momentary Assessment

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Mindfulness-based programs have demonstrated efficacy and effectiveness and have received growing recognition as evidence-based practices (for review: Creswell, 2017; Goldberg et al., 2018). Mindfulness has been described as intentionally turning non-judgmental attention toward current experience (Chiesa & Serretti, 2014, 2011; Creswell, 2017; Li et al., 2017). Mindfulness practice is the basis for psychological treatments targeting chronic pain and stress (Mindfulness Based Stress Reduction (MBSR): Kabat-Zinn, 1982, 2003), mood disorders (Mindfulness Based Cognitive Therapy (MBCT): Teasdale et al., 2000), as well as substance use disorders (Mindfulness Based Relapse Prevention; Bowen et al., 2014). Recent reviews suggest that the integration of mindfulness practice into treatment has been beneficial for treatment seekers experiencing various forms of psychopathology (Creswell, 2017; Goldberg et al., 2018). Previous investigations found similar effect sizes to empirically supported treatments, as well as improved durability of effects compared with controls and treatment as usual comparison conditions (Chiesa & Serretti, 2014, 2011).

Although a variety of operational definitions of mindfulness as a construct have been proposed (Kabat-Zinn, 2003; Langer & Moldoveanu, 2000), the current review uses Kabat-Zinn's definition. Mindfulness as a construct incorporates three core components: (1) purposefulness or intentionality, (2) a focus on direct or present moment experience, and (3) non-judgmentalness or kindness (Baer, 2006, 2011; Bishop et al., 2006; Brown, 2004; Chiesa & Serretti, 2011, 2014; Creswell, 2017; Kabat-Zinn, 2003; Li et al., 2017). Extensive efforts have been made to measure mindfulness as a latent factor using retrospective self-report methods. The most frequently used measures are the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003), and the Five Facet Mindfulness Questionnaire (FFMQ; Baer et al., 2006). Both measures quantify mindfulness as a relatively stable trait, and have received extensive psychometric examination demonstrating satisfactory discriminant and predictive validity (Baer et al., 2006; Brown & Ryan, 2003).

While research demonstrating the effectiveness of MBPs continues to be produced at a growing pace (Creswell, 2017; Goldberg et al., 2018), attempts to identify mechanisms of action using trait measurement methods have found mixed results (Bergomi et al., 2013; Bowen & Enkema, 2014; Creswell, 2017; Visted et al., 2015). Mechanisms of action are functional processes that explain the effects of an intervention on outcomes (Creswell,

2017). For example, two mechanisms of action in exposure therapy for phobias are expectancy violation and inhibitory learning (Craske et al., 2008, 2014). That is, the more exposure therapy violates expectations and promotes inhibitory learning, the more we see a reduction in anxiety. In the case of mindfulness interventions, hypothesized mechanisms have included processes that are both mindfulness-specific (e.g., acceptance, non-judgment) and non-mindfulness-specific (e.g., positive treatment expectancies) (Creswell, 2017). However, research into the mechanisms of mindfulness has thus far led to mixed results (Bergomi et al., 2013; Creswell, 2017). For example, while many studies have found a negative association between mindfulness and addictive behaviors (Bowen & Enkema, 2014), two studies evaluating the association between mindfulness and heavy drinking found a positive association (Leigh et al., 2005; Leigh & Neighbors, 2009). Measurement validity of mindfulness has also been called into question by a recent meta-analysis that reported 37 of 72 trials of MBPs failed to show an increase in trait mindfulness following training (Visted et al., 2015).

Inconsistent results may be due to methodological limitations. Assessment using retrospective self-report surveys that may not carry sufficient ecological validity or momentary precision to adequately assess mechanisms (Brown & Ryan, 2003). Indeed, efforts to use retrospective self-report methods to quantify mindfulness have received pointed criticism (Brown et al., 2011; Grossman & Van Dam, 2011; Grossman, 2011, 2010). One primary critique is that people are not able to accurately assess, recall, and report on their own attention with reliability between people and across populations (Bergomi et al., 2013; Grossman, 2011). Trait mindfulness self-report measures require individuals to recall their behavior across a variety of contexts over an extended period of time, which introduces bias. Although there may be some stable features of mindfulness as a psychological construct that are measurable as traits, inconsistent findings might be understood as artifacts of two specific limitations of the typical retrospective method of assessment: (1) the use of trait-level measurement does not match the hypothesized effects of mindfulness training, which occur at the state-level, or under specific physiological, psychological and environmental conditions, (2) the availability and representativeness heuristics impair validity of self-reports of awareness and attention as the time between event and recall increases (Brown & Moskowitz, 1997; Tversky & Kahneman, 1973, 1974; Uttl & Kibreab, 2011).

Intensive longitudinal assessment methods are well-suited to address limitations related to the ability of respondents to accurately assess, recall, and report on attention. Ecological momentary assessment (EMA), sometimes referred to as experience sampling methods (ESM), are intensive longitudinal assessment methods that increase validity when measuring latent constructs that change over time (Shiffman et al., 2008). EMA approaches consist of repeated measurement of constructs, typically via short surveys or brief diary prompts delivered via an electronic device such as a smart phone. Intensive longitudinal designs facilitate data collection on cognitive, affective, and physiological phenomena, which may occur only briefly, and thus be difficult to capture using retrospective self-report methods (Shiffman et al., 2008). EMA methods minimize recall bias, maximize ecological validity, and track how behavior and experience change over time and context. During EMA assessment periods, the length of time that people are reporting on is typically brief, on

the scale of hours rather than weeks or months. Intensive longitudinal assessment is a way of improving validity in measurement of phenomena that change over time, and may be particularly protective against biases of attention and recall (Brown & Moskowitz, 1997; Shiffman et al., 2008).

These aggregated estimates of mindfulness and mental health outcomes allow for traits to be measured as broad tendencies across a range of situations, while limiting dependence on memory. In addition to producing more reliable and valid measurement of mindfulness and mental health symptoms, EMA might also enable the testing of more nuanced theories (Shiffman et al., 2008). For example, repeated measurement of craving and mindfulness might reveal a link between average mindfulness and average craving at the between person level. In addition, EMA measurement enables investigation of a more subtle relationship at the within-person or momentary level, where momentary deviations from average mindfulness may be associated with momentary deviations from average craving. EMA data can investigate both of these questions analytically in ways that typical trait level assessment is not capable.

The main goals of the current literature review are threefold. Firstly, we aim to summarize findings from research applying intensive longitudinal assessment methods to the measurement of mindfulness and the effects of mindfulness training on mental health outcomes. Secondly, we intend to identify whether the pattern of mixed results from studies using trait measurements were likely to be an artifact of single timepoint assessment methodology or a feature of mindfulness that persists across assessment methods. Thirdly, the current review will address the relative utility of intensive longitudinal methods to investigate important questions regarding mechanisms for MBPs. To these ends, studies are reviewed if they measured mindfulness using intensive longitudinal methods or measured associated mental health outcomes using intensive longitudinal methods. A description of search methods is provided, followed by a systematic review of the literature evaluating research applying intensive longitudinal designs to investigate the effects of mindfulness on various mental health outcomes (i.e., depression, anxiety, affect, craving, and compulsive behaviors). Subsequently, we discuss the association between methods and mixed results, as well as the apparent strengths and limitations of different methodological approaches to measurement in the context of the mindfulness literature. Finally, recommendations are presented for future research using intensive longitudinal assessment methods to investigate how mindfulness and mindfulness training relate to mental health outcomes.

METHOD

Protocol

The current review was conducted following the guidelines outlined in the PRISMA statement: http://www.prisma-statement.org (Page & Moher, 2016). First, a search of PsycINFO and Web of Science was completed to identify already existing systematic reviews, meta-analyses, and literature reviews on associations between mindfulness and mental health using ecological momentary assessment. None were found. Thus, search terms were refined, and a new search was completed from the earliest available publications through August 2018. A formal review protocol was not pre-registered online.

Eligibility criteria

Articles were included if they (1) were published or in press before September 2018, (2) were written in English, (3) included both "mindfulness" and "ecological momentary assessment" or "experience sampling" in the abstract, title, or text of the article, and (4) reported results that are not described elsewhere in the literature related to the association between mindfulness and mental health outcomes from analysis of intensive longitudinal data.

Search outcome

A flow diagram detailing article selection is available in Figure 1. The search strategy produced a total of 84 articles. All articles were exported to Zotero referencing software and were manually reviewed and selected or removed based on the four criteria described above. Thirty-three articles were excluded because they were duplicates, 13 articles were excluded because they did not utilize intensive longitudinal methods in the study design, 14 articles were excluded because they did not report results from analysis of intensive longitudinal assessment of mindfulness and/or mental health outcomes and their association, and two additional articles were excluded because they reported results that were described elsewhere in the literature.

A total of 22 articles remained that met all four criteria for the current review, reporting results from 23 different studies. One article reported results from two studies, both of which were included in the current review.

Article Summaries

Results were extracted and summarized directly from studies, and risk of bias based on sample, study design, and analysis was assessed at the level of each study. Sample size, population, study design characteristics, mindfulness measures and scale type, and statistical results were extracted and considered.

RESULTS

Studies included in the current review

A review of the 22 articles investigating the effect of mindfulness or mindfulness training on mental health outcomes measured using intensive longitudinal designs was completed. All 22 articles reported results on the outcome variable using intensive longitudinal assessment methods. Outcomes included affect, craving, consumption, depression, rumination, anxiety, emotion lability, and non-suicidal self-injury. The majority of studies reported an association between mindfulness or mindfulness training with affect alone (7) or affect and at least one other outcome (9). A smaller number of studies reported results for outcomes that did not include affect (7). The sample sizes and demographic characteristics, study designs, measurement methods, and outcome variables are available in Table 1. Two studies collected both retrospective data and intensive longitudinal data (one measured mental health outcomes, and one measured both mindfulness and the mental health outcome), and reported on the relative differences between using intensive longitudinal assessment and trait-level panel assessments (Brown & Ryan, 2003; Moore et al., 2016).

Results from each of the 23 studies are briefly summarized below, organized by mental health outcome. Studies fell into two general design categories; 8 were observational and 15 were experimental. Eight studies measured mindfulness as a state using intensive longitudinal assessment, nine studies measured mindfulness as a trait using single timepoint assessment, and eight studies included an intervention and did not measure mindfulness at all. More specific information regarding categorizations for each study is available in Table 1.

Decreases in negative affect and increases in positive affect

Thirteen studies reported results on the association between mindfulness and affect. Eight studies used an experimental design including a mindfulness training intervention, and five studies used an observational design.

Experimental studies—In a randomized controlled trial comparing MBCT to wait-list control, those in the mindfulness training condition experienced positive emotions more frequently, and also reported more frequent engagement in and increased responsiveness to pleasant activities (Geschwind et al., 2011). Participants were adults with a history of depression and current residual depressive symptoms, randomized to MBCT (n=64), or waitlist control (n=66). Intensive longitudinal assessment was used to assess momentary positive emotions and activity pleasantness during a six-day period before and after the intervention. Participants in the mindfulness training condition experienced significant increases in reported positive affect (β =.39, p<.01) and activity pleasantness (β =.22, p<.01), as well as a greater ability to boost current positive affect by engaging in pleasant activities (β=.08, p<.01). The implications of these findings are limited by the lack of active control.

In a secondary analysis (Garland et al., 2015) of data collected in the above-mentioned trial (Geschwind et al., 2011), results revealed a positive association between receiving mindfulness training and current moment positive affect (β=.39, p<.01), a negative association with current moment negative affect (β=.22, p<.01), and increased momentary positive cognitions. Investigators also tested a hypothesized "upward spiral" model of interaction between positive affect and cognitions with intensive longitudinal data using an autoregressive latent trajectory model. Results, although preliminary, were promising (Garland et al., 2015), suggesting that positive affect was more tightly predictive of subsequent positive cognitions for individuals in the MBCT condition, although cognitions did not predict subsequent affect.

An RCT of Mindfulness-Oriented Recovery Enhancement (MORE) compared to a support group control condition investigated the effects of mindfulness on pain and affect for 55 chronic pain patients on opioid pharmacotherapy (Garland et al., 2017). Findings indicated that the MORE group had greater decreased momentary pain (B=−0.003, SE=0.001, p=0.01), decreased overall pain (B=−0.002, SE=0.001, p=0.03) and significantly increased positive affect over time (B=0.003, SE<0.001, p=0.001) compared to the control group. Additionally, the MORE group was more likely to demonstrate positive affect regulation, defined as a greater ability to maintain and recover positive affect.

A pilot parallel group randomized controlled trial (Ruscio et al., 2015) compared a brief mindfulness meditation practice intervention with control meditation practice in a sample of community smokers (*N*=44). Participants completed assessments 4 times per day, meditated once per day using guided meditations, and tracked cigarette use daily, with the instruction to smoke as much or as little as they liked during the study. Individuals in the mindfulness intervention reported significantly less momentary negative affect than the control group (*B*=−2.78, *p*<.001). However, negative affect was not reduced following meditation practice, nor did it decrease over time. Investigators noted that these results are consistent with findings from urge surfing research (an approach to craving informed by acceptance and mindfulness as opposed to suppression and distraction), and could also be attributable to a floor effect for the negative affect measure (Bowen & Marlatt, 2009; Rogojanski et al., 2011; Ruscio et al., 2015).

In an investigation of the effects of mindfulness training on mindfulness, decentering (learning to treat negative thoughts as events rather than truth), and affect, intensive longitudinal assessment was utilized during a three-week mindfulness training program (Shoham et al., 2017). Participants were 82 meditation-naive adults from the general community, who completed assessments 2–3 times per day throughout the training program. Participants demonstrated significantly increased mindfulness and decentering over the course of the training, with larger effects during meditation practice (β=.47, *SE*=.05, *p*<.001) than during daily living (β=.25, *SE*=.04, *p*<.001). Increased mindfulness led to significantly increased positive emotion both during meditative states (β=.45, *SE*=.09, *p*<.001) and in daily life (β=.17, *SE*=.06, *p*=.003). Decentering was not related to emotional valence.

Individuals with prior mindfulness experience who had completed either MBSR or MBCT (N=29) engaged in mindful walking beside the river Rhine accompanied by assessments of state mindfulness and affect (Gotink et al., 2016). Compared to the control period, over the course of the mindful walking period participants experienced significant increases in positive affect (β=0.91, *p*<0.01) and state mindfulness (β=0.98, *p*<0.01), as well as decreased negative affect (β=−0.71, *p*<0.01). State mindfulness at the previous assessment predicted positive affect in the next, even controlling for affect at the prior assessment (β=0.18, *p*<0.01). The reverse was also true with positive affect predicting later mindfulness (β=0.21, *p*<0.01). Negative affect had an opposite relationship, such that mindfulness predicted reduced later negative affect (β=−0.14, *p*<0.001), and negative affect predicted reduced state mindfulness at the next assessment (β=−0.19, *p*<0.001). Analyses between days showed an opposite relationship, as positive affect on the previous day significantly predicted reduced mindfulness on the next, controlling for mindfulness the day before (β=−0.36, *p*=0.027), and negative affect on the previous day predicted increased mindfulness on the next day (β=0.41, *p*=0.002). State mindfulness and positive affect also significantly improved with number of days walked.

Another recent study examined the effects of Compassion Cultivation Training (CCT) on affective states, assessed twice daily, such as anxiety, calmness, fatigue, and alertness, as well as affective regulatory strategies, assessed weekly (Jazaieri et al., 2018). Participants were 51 adults without psychiatric symptoms. This paper utilized a subsample from a larger RCT, including only those individuals who were randomized to the CCT condition.

CCT comprised weekly two-hour classes and daily compassion-focused meditation for eight weeks. Over the duration of the course, participants had significant decreases in anxiety ($\gamma=-.02$, $p=.01$) and increases in calmness ($\gamma=.04$, $p<.01$), as well as increased self-efficacy to regulate affective states. However, participants endorsed less desire to regulate affective states, presumably because their affect became less aversive over the course of training. Finally, over the course of training, the use of suppressive affect regulation strategies decreased, while use of acceptance increased. Results must be interpreted with caution due to the lack of control condition.

A comparison of the effectiveness of acceptance and avoidance-based emotion regulation strategies for different psychiatric populations indicated that mindfulness components may have variable effectiveness for different disorders (Chapman et al., 2017). Participants were 48 individuals diagnosed with Borderline Personality Disorder (BPD), 54 diagnosed with Major Depressive Disorder (MDD), and 50 non-psychiatric controls. Participants were randomly assigned to receive instructions on strategies for regulating emotions involving either acceptance or avoidance, then completed intensive longitudinal assessments at random time points 8 times per day for 6 days. The first 2 days were used to establish a baseline, the middle 2 days participants were instructed to use specific strategies, and the final 2 days had no specific instructions. Individuals with BPD reported significantly decreased negative affect on days they were instructed to use avoidance strategies ($\beta=-.13$, $SE=.05$, $p=.01$), as well as significantly decreased urges for maladaptive behavior ($\beta=-.11$, $SE=.03$, $p<.01$). Additionally, the MDD acceptance group had significantly decreased negative affect between the instruction phase and the final two days ($\beta=-.10$, $SE=.05$, $p=.04$) indicating that this strategy was helpful in the short term for individuals with MDD.

Observational studies—Two samples were gathered to examine the relationship between mindfulness and affect for adult community members and young adult college students (Brown & Ryan, 2003). Participants were 83 adult community members recruited through newspaper and poster advertisements (Sample 1), and 92 young adult college students enrolled in introductory psychology courses (Sample 2). Dispositional mindfulness (MAAS; Brown & Ryan, 2003) and dispositional affect (Diener & Emmons, 1984) were measured at baseline, followed by a period of experience sampling assessing state mindfulness and state affect. Using aggregated intensive longitudinal data, baseline trait mindfulness was negatively associated with average negative affect (Sample 1: $r=-.49$, $p<.01$; Sample 2: $r=-.33$, $p<.01$) and was not associated with positive affect. Using a multilevel modeling approach, trait mindfulness was negatively associated with momentary negative affect ($\beta=-.47$, $p<.01$; $\beta=-.26$, $p<.01$), and not significantly associated with momentary positive affect. Momentary mindfulness, however, was positively associated with current moment positive affect ($\beta=.25$, $p<.01$) and negatively associated with current moment negative affect ($\beta=-.22$, $p<.01$). Investigators noted that the momentary measure demonstrated stronger psychometric qualities than the trait measure (Brown & Ryan, 2003). The contrast between trait-level and momentary measurement is discussed in more detail in a later section of the current review (*Comparing panel data outcomes to intensive longitudinal outcomes*).

The relationship between mindfulness, motivational conflicts, and affect was also investigated using intensive longitudinal assessment (Grund et al., 2015). Participants were 58 university students. Participants responded to questions about motivational conflicts and affect in their daily life 6 times per day for 7 days. Models used aggregated affect as the outcome (a summary score of positive activation, negative activation, and affect valence), as measured in the moment during intensive longitudinal assessment, and the Short Scale of Positive and Negative Activation and Valence, modeled on the Positive and Negative Affect Scales (PANAS: Watson, Clark, & Tellegen, 1988). Results indicated that there was a positive direct effect between mindfulness and aggregated positive affect (β=0.20, p<0.01) after controlling for self-control and motivational conflicts.

Investigating the validity of a newly developed Multidimensional State Mindfulness Questionnaire (MSMQ), Blanke Riedeger & Brose (2018) found similar associations between two of three subscales and affect. The MSMQ includes three subscales: present-moment attention, acting with awareness, and nonjudgmental acceptance. Participants were 70 young adult college students and community members who completed 6 surveys per day for 9–12 days. There was a positive main effect of the attention (β=.27, SE=.03, 95% CI [0.22, 0.32]) and nonjudgment (β=.17, SE=.02, 95% CI [0.13, 0.21]) subscales of the MSMQ on positive affect. Negative associations were observed between these same two subscales, attention (β=−.12, SE=.02, 95% CI [−0.16, −0.07]) and nonjudgment (β=−.26, SE=.02, 95% CI [−0.30, −0.23]), and negative affect. There was also a significant interaction between these two subscales predicting negative affect, indicating that in moments of high nonjudgmental acceptance, the association between variability in present-moment attention and negative affect was reduced. Finally, the nonjudgmental acceptance subscale moderated the association between life stressors and affect, such that higher nonjudgmental acceptance reduced the strength of the association.

Felsman, Verduyn, Ayduk, & Kross (2017) investigated the association between present focused awareness and affect valence. Experience sampling was carried out to assess attentional orientation (past, present, future) and affect valence in a community sample of adults and college students (N=64), with 5 surveys per day for 7 days. In the concurrent model, present-focused attention predicted an increase in momentary positive affect relative to future-or past-focused attention (B=4.37, SE=1.28, 95% CI [1.85, 6.88]). The time-lagged model was not significant for present-focus predicting affect.

A study of mindfulness and social interactions (Quaglia et al., 2015) was conducted with 72 people in 37 romantic couple relationships. Participants rated their affect following each social interaction they were involved in for the next six days. Trait mindfulness was negatively associated with momentary negative affect (B=−2.18, SE=.47, 95% CI [−3.12, −1.24]), and positively associated with momentary positive affect (B=1.27, SE=.45, 95% CI [0.36, 2.17]) following social interactions that were five minutes or longer.

Decreases in symptoms of depression, rumination, and anxiety

Five studies reported results from investigations of the associations between mindfulness and depression symptoms, rumination and/or anxiety. Three studies used an experimental design to investigate the association, and two studies used an observational design.

Experimental studies—In a RCT treatment comparison study (Moore et al., 2016), 67 people aged 65 or older with depression and anxiety were assigned to one of two intervention conditions: MBSR, or a health education control. Study participants completed EMA assessments 10 days prior to and after treatment. Trait and state mindfulness increased among MBSR participants, and depression and anxiety symptoms significantly decreased compared with the health-education control. The estimated Number-Needed-to-Treat (NNT) when using EMA to evaluate the effect of the intervention on depression symptoms was 8.2, whereas the NNT was 31.1 when using the more standard method of single time panel data collection (Moore et al., 2016). The estimated NNT for anxiety symptoms did not differ by data capture method.

The results of a study by Felsman, Verduyn, Ayduk, & Kross (2017) were discussed previously in this review, and this section will report on the association between mindfulness and negative rumination. For the concurrent model, focusing on the present was negatively associated with momentary negative rumination (B=−12.10, SE=2.26, 95% CI [0.13, 0.21]). The time-lagged model indicated no significant association between present-focus and negative rumination.

The previously described study by Geschwind et al. (2011) also reported results related to depression symptoms. For those who received MBCT training, appraisal of positive emotion (b=.05, 95% CI [.00, .10]), activity pleasantness (b=.30, 95% CI [.26, .34]), and reward experience (b=.06, 95% CI [.02, .09]), were all associated with reduced symptoms of depression. Findings indicated that changes in depressive symptoms following MBCT may be related to increased momentary positive emotion, activity pleasantness and reward experience.

Observational studies—A recent study by Naragon-Gainey & DeMarree (2017) investigated two different facets of decentering – a construct highly correlated with facets of mindfulness – and their relation to psychopathology and affect. The two factors were observer perspective (OP), defined as relating to thoughts in an objective, distant manner, and reduced struggle with inner experience (RS), defined as a decreased impact of thoughts and feelings on subsequent responses. Authors hypothesized that decentering would moderate the link between affect and dysphoria. The hypothesis was tested in an adult community sample of 135 individuals currently receiving mental health treatment. Participants completed 10 days of smartphone surveys 3 times per day. OS was negatively associated with daily dysphoria (β=−.30, SE=.07, p<.01). RS was also negatively associated with daily dysphoria (β=−.21, SE=.04, p<.01) Significant interactions between both decentering constructs and NA were observed for both dysphoria and worry as outcomes. In both cases, the interaction between decentering and negative affect indicated an attenuation of the association between negative affect and the outcome.

Another study examined the relationship between mindfulness, state and trait rumination, and state and trait anger (Borders & Lu, 2017). A total of 171 participants completed assessments either 2 or 6 times per day for 7 days, and these assessments were analyzed both concurrently and cross-lagged. Cross-lagged analyses indicated that trait mindfulness was a significant predictor of state rumination (B=−.04, SE=.01, p<.01) and interacted

with state anger to predict state rumination. The interaction indicated that for individuals with high levels of trait mindfulness, trait mindfulness attenuated the association between state rumination and state anger. State rumination was also a mediator of the relationship between trait mindfulness and state anger. This pattern of results points to a protective effect of mindfulness, as those high in mindfulness ruminated less and experienced a weaker association between anger and rumination.

Increases in emotion awareness and lability

Emotion awareness and lability were examined in three studies. One study utilized an experimental design, and the other two studies used an observational design.

Intervention study—A mindfulness-based intervention trial was conducted, focused on improving participants' ability to differentiate negative and positive emotions among a sample of 61 adults (after exclusion for attrition; Van der Gucht et al., 2019). A within-subjects design was used to examine participants pre-, post-, and at 4 months follow-up with regard to the intervention. During each assessment period, participants completed ESM reports up to 40 times for 4 days. Each phase was also accompanied by retrospective self-report measures, including a measure of emotional distress and the Comprehensive Inventory of Mindfulness Experiences (CHIME; Bergomi et al., 2013). Results showed an improvement in ability to differentiate negative emotions post-intervention (B=−0.10, p=.012) and at follow-up (B=−0.12, p=.028). However, this improvement was no longer significant after controlling for negative affect. There was also an improvement in ability to differentiate positive emotions at follow-up (B=−0.09, p=0.43). Finally, posttreatment state and trait mindfulness skills mediated changes in ability to differentiate negative emotions even when controlling for negative affect. With regard to state mindfulness, nonjudgmental acceptance/decentering mediated the improvement in ability to differentiate negative emotions. With regard to trait mindfulness, the same was true for accepting and nonjudgmental orientation and decentering and non-reactivity.

Observational studies—In an observational study to investigate the mechanisms of action in mindfulness training, investigators used the FFMQ to assess mindfulness at baseline, and intensive longitudinal methods to assess 21 different emotions approximately every 2 hours for 10 days (Hill & Updegraff, 2012). Participants were college students (N=103). Results indicated that overall mindfulness at baseline was negatively associated with the index of emotion differentiation (r=−.22, p=.03), such that greater mindfulness predicted greater negative emotion differentiation. Additionally, overall mindfulness was negatively associated with negative emotion lability (r=−.38, p<.05) and positive emotion lability (r=−.26, p<.05), or patterns of change from positive emotionality to negative emotionality. Follow-up analyses revealed that the non-reactivity sub-scale of the FFMQ was driving the effect for both emotion differentiation and emotion lability.

In an earlier mentioned observational study of social interaction with 37 couples (*N*=74), investigators also assessed emotion lability (Quaglia et al., 2015). Results revealed mindfulness to be negatively associated with negative emotion lability (B=12.83, p=.02). Positive emotion lability was not associated with MAAS scores at baseline.

Decreases in craving and unhealthy consumption

All six studies that focused on the association between mindfulness and craving and/or unhealthy consumption applied an experimental design in their investigation.

Experimental studies—Participants in a RCT were adult smokers (n=176) interested in tobacco cessation (Nosen & Woody, 2013). Cigarette craving and use were assessed using EMA during the 24-hour period following the three-condition intervention (mindfulness psychoeducation, psychoeducation, and no psychoeducation). Growth curve models were tested to assess craving trajectories reported by participants in all three conditions. Results indicated that on average, participants who received mindfulness psychoeducation experienced a unique trajectory of craving over the 24-hour period, such that craving peaked mid-day, and was reported to be significantly less at end of day than control. Additionally, mean craving scores were significantly lower among abstainer participants in the mindfulness psycho-education group after being awake for 10 hours (p<.05).

A RCT evaluating the comparative and combinatory effectiveness of mindful decision-making training (MDT) and inhibitory control training (ICT) for eating behaviors found that only the two conditions that included mindful decision-making training were associated with decreases in craving-related eating (Forman et al., 2016). Participants were 119 undergraduate students recruited through local advertising or psychology courses, who were then randomized to one of four training conditions: MDT, ICT, Combined MDT/ICT, and psycho-educational control. Participants completed EMA reports 3 times per day for 7 days before and after the intervention. Participants in all four conditions, including control, reported a reduction in frequency of salty snack consumption during the post-treatment phase of EMA. Only individuals in the combined MDT/ICT condition experienced significantly greater reductions in consumption compared to control (p=.02).

In a previously mentioned parallel group RCT (Ruscio et al., 2015), a main effect of the mindfulness meditation intervention was observed, such that individuals in the mindfulness intervention reported significantly less momentary craving than the control group after completing a meditation practice (B=.81, p<.01). Additionally, individuals in the mindfulness group reported declining rates of daily cigarette usage over the course of the study, whereas cigarette usage in the control group did not change (B=−.29, p=.01).

With regard to opioid use outcomes, the previously described RCT of MORE by Garland et al. (2017) also found unique benefits for the mindfulness intervention group (MORE) when compared with the control group. MORE participants had significantly decreased opioid misuse scores at the end of treatment, (B=3.82, SE=0.24, p<0.01). Improvements in positive affect, but not pain, were also significantly associated with reduced risk of opioid misuse at the end of treatment.

Some results of Chapman et al. (2017) were discussed earlier in this review, and this section includes additional results regarding urges. Instructions to avoid negative emotions were associated with reduced urges for maladaptive behaviors (β=−.11, SE=.03, p<.01) among participants diagnosed with BPD (n=48). This association was not found for participants with either major depressive disorder (n=54) or no psychiatric diagnosis (n=50). Authors

posit that these acceptance strategies take longer to learn and that for short term relief, avoidance strategies can be effective, at least for those with a BPD diagnosis.

Another study implemented a 28-day (self-paced) smartphone-delivered intervention for craving-related eating using mindful eating practices with 104 overweight or obese women (Mason et al., 2018). EMA via text message was used pre-intervention and 1-month post-intervention to assess food cravings. Participants (*n*=78) completed the intervention, and experienced reductions in craving-related eating (*OR*=0.729, *p*<.01) and trait craving (*b*=14.27, *p*<.01). Implications of the results are tempered by the absence of randomization or a control condition.

Decreases in non-suicidal self-injury

One study examined the individual and combined effects of mindful emotion awareness and cognitive reappraisal interventions on non-suicidal self-injury (NSSI) in a sample of 10 self-injuring adults using an experimental design (Bentley et al., 2017). Participants were randomized to receive either the mindful emotion awareness or cognitive reappraisal and flexibility module of the Unified Protocol for Transdiagnostic Treatment of Emotional Disorders (Farchione et al., 2012), and participants who did not respond to their assigned intervention also received the other intervention. EMA was used to assess daily ratings of NSSI urges and acts throughout the study. Results indicated that 8 of the 10 participants experienced clinically meaningful reductions in NSSI, with 2 participants requiring both interventions. Group analyses showed a significant effect of study phase on NSSI, whereby NSSI urges (*p*<.01) and acts (*p*<.01) decreased following the introduction of the study phase.

Comparing trait mindfulness and state mindfulness as predictors

One study assessed baseline trait mindfulness in addition to momentary mindfulness using intensive longitudinal assessment method (Brown & Ryan 2003). Results from multilevel modeling indicated that the majority of variance in state mindfulness was attributable to within-person variability as opposed to between-person variability, indicating there was substantial variability in momentary mindfulness over time. Specifically, only 29% of the variance in state mindfulness was attributed to between-person differences, and 71% was attributed to within-person differences. In addition, the association between state mindfulness and positive affect was significant (*B*=0.25, *p*<0.01), whereas the association between momentary positive affect and trait mindfulness was not. Investigators hypothesized that this difference in observed effect maybe be due to the superior ecological validity of momentary assessment in addition to increased temporal proximity (Brown & Ryan, 2003).

Comparing panel data outcomes to intensive longitudinal outcomes

One study was conducted that assessed outcomes using both intensive longitudinal methods and typical retrospective self-report measures (Moore et al., 2016), allowing for a comparison between the assessment methods. Mindfulness training was associated with a significant reduction in depression, regardless of assessment method. However, the effect of the intervention was much larger for intensive longitudinal outcomes (*d*=0.4), when compared with retrospective self-report measures completed at the research center (*d*=0.1). If the researchers had used only panel data (NNT=31.1), they would have found an effect

more than three times smaller than the effect they found when using intensive longitudinal methods (NNT=8.2).

DISCUSSION

The current review summarized findings in the literature investigating the associations of mindfulness and mindfulness training with mental health outcomes measured using intensive longitudinal methods. The three main goals of the current review were to (1) summarize the relevant literature, (2) identify whether there were inconsistent results, as has been reported in the mindfulness literature previously, and (3) address the relative utility of intensive longitudinal methods. The first of the three main goals was met by summarizing relevant literature in narrative form and also as a table.

The second goal was met, and the current review revealed a consistent pattern of results suggesting a negative association with mental health outcomes across 23 studies (i.e., increased mindfulness or experience with mindfulness training were associated with decreased mental health difficulties). While the trend supported the primary hypothesis of the current study, the uniformity of results may also reflect publication bias. Across the studies described in the 22 articles, primary outcomes were positive and negative affect, depression symptoms, craving, and substance use. A negative association between mindfulness and negative affect was reported in ten studies, craving in four studies, consumption in three studies, depression in three studies, rumination in two studies, emotion lability in two studies, anxiety in one study, and NSSI in one study. A positive association between mindfulness and positive affect was reported in nine studies and emotion awareness in two studies. Results included 15 experimental studies reporting results following interventions, and 8 studies describing observational findings from non-interventions. These results are consistent with a much larger body of evidence demonstrating the effectiveness of mindfulness interventions for reducing mental health problems (Creswell, 2017). The consistency of the findings in this review suggests that the mixed results from studies using trait measurements with single timepoint assessment methods (Visted et al., 2015) may be an artifact of methodology as opposed to a feature of mindfulness that persists across assessment methods (Grossman, 2011).

The third goal was met, as the review identified two studies that used both intensive longitudinal methods and trait-level panel longitudinal methods (Brown & Ryan, 2003; Moore et al., 2016). Findings from both studies suggested that intensive longitudinal assessment may provide a more sensitive and valid measure of mindfulness, affect, and depression. Of note, there was no significant difference between data capture methods (EMA or typical methods) for anxiety. More research to investigate the question of relative strengths of intensive longitudinal assessment for research on mindfulness and mental health outcomes is sorely needed.

Limitations

The results of the current review should be understood to be preliminary and come with substantial caveats. First, it should be noted that the literature reviewed is still in a nascent stage, with the majority of studies focusing on affect. Among the 15 studies that did

report results outside of affect, there were five different outcomes, resulting in limited data per mental health outcome. Measurement within mental health constructs varied, limiting the comparisons that can be made across studies. Additionally, the uniform direction of effects may reflect publication bias, which would impact the availability of data to be included in the current review. While this consideration does not necessarily indicate that the results reported are not valid, the reliability of the direction and magnitude of the effect of mindfulness on mental health outcomes measured using EMA ought to be considered preliminary until more results are available.

Second, the inferences that can be drawn from these studies in aggregate are limited by the lack of uniformity in the facets of mindfulness measured. Among the eight studies that assessed state mindfulness, each study used a unique item. Among the 11 studies that assessed trait mindfulness, three studies used the MAAS, two used the FFMQ, and six other studies used six separate measures.

Third, concerns exist regarding the sensitivity of current retrospective self-report measures of mindfulness and how trait mindfulness relates to phenomena that are highly time-variant, such as craving and affect (Bergomi et al., 2013; Grossman, 2010; Uttl & Kibreab, 2011; Witkiewitz et al., 2014). Among studies assessing mindfulness in the current review, the majority used retrospective self-report tools such as the MAAS and FFMQ to measure mindfulness as a trait. Investigators have raised concerns regarding trait measurement (Grossman, 2011; Grossman & Van Dam, 2011; Visted et al., 2015). Indeed, the availability and representativeness heuristics may lead respondents to report in reliable, but not valid ways (Tversky & Kahneman, 1974, 1973; Uttl & Kibreab, 2011). The only two studies that reported on state and trait mindfulness found that momentary mindfulness scores differed substantially from trait scores, providing evidence to support the hypothesis that biases of attention may influence validity of self-report assessment of mindfulness and mental health outcomes (Brown & Ryan, 2003; Moore et al., 2016).

Finally, the current study did not directly address the issue of identifying active ingredients of mindfulness-based programs. While the identification of active ingredients is certainly a useful and important question to investigate further and several studies included in the current review did explore hypothesized active ingredients, further exploration was beyond the scope of this work.

Future Directions

Results from the current study have substantial implications for future research on mindfulness as a construct, how mindfulness relates to mental health outcomes, and how clinical research on mindfulness-based programs is conducted. More studies using EMA would improve the reliability of the findings on the association between mindfulness and mental health. Examining mechanisms for the purpose of program development and improvement is an essential next step for research in this area, and EMA is uniquely well suited to investigating mechanisms of action in mindfulness-based programs. More studies are needed to compare state mindfulness to trait mindfulness, and how and whether these dimensions of mindfulness relate to mental health in different ways. Additionally, meta-analysis comparing effect sizes from studies that collected intensive data with effect

sizes from studies using typical designs would to clarify how assessment method type is related to associations between mindfulness and mental health outcomes.

Conclusion

Researchers seeking to increase validity of results should consider incorporating intensive longitudinal assessment methodology into their study designs and may benefit from using a validated measure like the MSMQ. Using intensive longitudinal assessments will also increase measurement precision for highly variable experiential phenomena vulnerable to recall and cognitive biases, and thus increase the validity of findings by assessing change over time. Future research on mindfulness and mindfulness training will benefit from enhanced assessment precision by using intensive longitudinal assessment and may reveal a clearer and more consistent picture of the role mindfulness plays in mental health.

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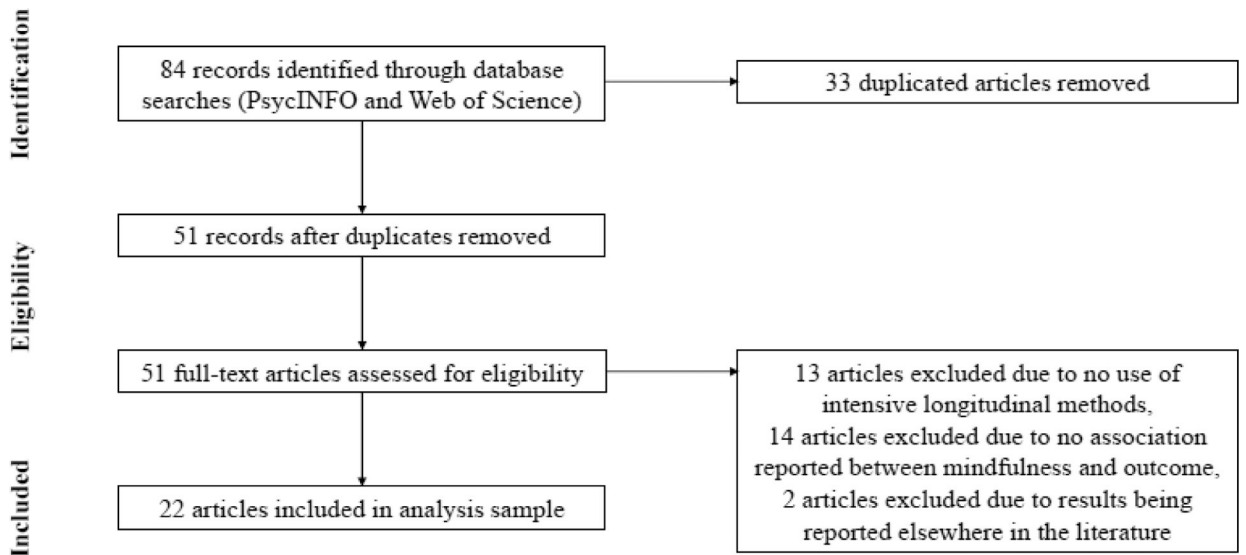
Figure 1.
Flow diagram detailing article selection

Table 1.

Literature review of associations between mindfulness and mindfulness-based interventions on mental health

Reference	Sample		Design	Mindfulness		Outcomes	Significant results
	Characteristics	N		Measure	Type		
Bentley, 2017	Self-injurious adults	10	Experimental	None	N/A	NSSI	Improvement in mindful emotion awareness over the course of the study and decreased self-injury.
Blanke, 2018	Community adults	70	Observational	MSMQ	State	Affect	Increased positive affect and decreased negative affect were predicted by the attention and nonjudgmental acceptance subscales of the mindfulness measure. Significant interactions such that nonjudgmental acceptance reduced the strength of the association between life stressors and negative affect.
Borders, 2016	College students	171	Observational	FMI	Trait	Rumination	Trait mindfulness negatively predicted momentary rumination and interacted with momentary anger to predict increased momentary rumination. High trait mindfulness attenuated the association between prior momentary rumination and current momentary anger.
Brown & Ryan, 2003							
Study 1	College students	92	Observational	MAAS	Trait	Affect	Increased trait mindfulness predicted decreased momentary negative affect.
Study 2	Community adults	41	Experimental	MAAS	Trait and State	Affect	Momentary mindfulness was associated with increased momentary positive affect and decreased momentary negative affect. Substantial variability in momentary mindfulness not captured by trait measurement.
Chapman, 2017	BPD, MDD, Controls	152	Experimental	State	State	Affect, Craving	Individuals with BPD experienced decreased negative affect and urges for maladaptive behaviors when using avoidance strategies. Individuals with MDD had significantly decreased negative affect when using acceptance strategies and increased willingness to tolerate distress.
Felsman, 2017	Community adults	64	Observational	Single item	State	Affect, Rumination	Increased within-person positive affect when awareness was present focused. Increased present moment awareness indirectly predicted increased life satisfaction through reducing rumination.
Forman et al., 2016	College students	119	Experimental	None	N/A	Craving, Use	Only individuals in the combined mindfulness and inhibitory control condition experienced significantly decreased consumption of salty snack foods compared to psychoeducational control condition.
Garland et al.,2015	Prior MDD diagnosis	130	Experimental	None	N/A	Affect	Increased momentary positive affect. Decreased momentary negative affect.
Garland, 2017	Chronic pain	55	Experimental	None	N/A	Affect, Use	Individuals in mindfulness group experienced decreased momentary pain, decreased overall pain and increased positive affect. Individuals in mindfulness group had decreased likelihood of opioid misuse at the end of treatment, associated with increased positive affect.
Geschwind et al., 2011	Prior MDD diagnosis	130	Experimental	None	N/A	Affect, Depression	Increased positive affect. Increased activity pleasantness. Increased ability to boost positive affect. All these increases were associated with decreased depression symptoms.
Gotink, 2016	Community adults	29	Experimental	FFMQ	State	Affect	Increased positive affect. Decreased negative affect. Increased mindfulness. State mindfulness predicted increased momentary positive affect and decreased momentary negative affect. Momentary positive and negative affect predicted increased and decreased state mindfulness, respectively.

Reference	Sample		Design	Mindfulness		Outcomes	Significant results
	N	Characteristics		Measure	Type		
Grand et al., 2015	58	College students	Observational	MAAS	Trait	Affect	Mindfulness was positively associated with aggregated affect.
Hill et al., 2012	96	College students	Observational	FFMQ	Trait	EA, EL	Mindfulness at baseline was associated with greater ability to differentiate between emotions, and lower emotional lability.
Jazaieri, 2018	51	Community adults	Observational	None	N/A	Affect	Increased calmness, self-efficacy to regulate affect, and use of acceptance-based regulation strategies. Decreased anxiety, desire to regulate affect, and use of suppression-based affect regulation strategies.
Mason, 2018	104	Community adults	Experimental	None	N/A	Craving, Use	Reductions in craving related eating and trait craving.
Moore et al., 2016	67	Anxious/depres sed seniors	Experimental	CAMS-R	Trait and State	Anxiety, Depression	Participants in the mindfulness training condition reported increased trait and state mindfulness, decreased depression and anxiety. The intervention's effect on state mindfulness and depression was stronger when measured by EMA rather than by retrospective measures. No difference in assessment type for anxiety.
Naragon-Gainey, 2017	135	Mental health tx seekers	Observational	EQ, TMS, DDS, CFQ, BAFT	Trait	Depression	Decentering and daily affect were associated with daily symptoms in expected directions. Interactions between decentering and negative affect indicated that as decentering increased, negative affect was less predictive of symptoms.
Nosen et al., 2013	176	Community smokers	Experimental	None	N/A	Craving	Participants in the mindfulness condition reported decreased craving overall, and unique daily craving trajectory such that craving peaked midday and decreased significantly relative to control by end of day.
Quaglia et al.,2015	72	College students	Experimental	MAAS	Trait	Affect, EL	Trait mindfulness predicted increased positive affect and decreased negative affect after social interactions. Mindfulness was negatively associated with negative emotion lability.
Ruscio et al., 2015	44	Community smokers	Experimental	None	N/A	Affect, Craving	Participants in mindfulness condition reported decreased momentary negative affect. Individuals in mindfulness condition experienced decreased craving after mindfulness practice, and decreased cigarette use overall.
Shoham, 2017	82	Community adults	Experimental	MAAS, SMS, EQ, TMS	State	Affect	Increased mindfulness and decentering overall, with largest effects during mindfulness practice. Increased positive affect during mindfulness practice and daily life due to increased mindfulness.
Van der Gucht,2019	61	Community adults	Experimental	CHIME	Trait and State	EA	Increased ability to differentiate positive and negative emotions. Posttreatment state and trait mindfulness were mediators of increased ability to differentiate emotions.

Note. All outcomes were measured using intensive longitudinal methods. Mindfulness was treated as a state construct, a trait construct, and/or as an experimentally manipulated variable. The "Measure" column identifies the measure name for those studies that measured the construct, and the "Type" column identifies how the study treated the construct (trait, state, or both). BAFT = Believability of Anxious Feelings and Thoughts. CAMS = Cognitive and Affective Mindfulness Scale. CHIME = Comprehensive Inventory of Mindfulness Experiences. CFQ = Cognitive Fusion Questionnaire. DDQ = Drexel Defusion Scale. EA = Emotional awareness. EL = Emotion lability. EQ = Experience Questionnaire. FMI = Freiburg Mindfulness Inventory. MAAS = Mindful Attention and Awareness Scale. MSMQ = Multidimensional State Mindfulness Questionnaire. SMS = State Mindfulness Scale. TMS = Toronto Mindfulness Scale.