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# Experimental Effects of Mindfulness Inductions on Self-Regulation: Systematic Review and Meta-Analysis

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Self-regulation is the control of aspects of the self to allow pursuit of long-term goals, and it is proposed as a central pathway through which mindfulness may exert benefits on well-being. However, the effects of a single mindfulness induction on self-regulation are not clear, as there has been no comprehensive review of this evidence. The current review synthesized existing findings relating to the effect of a mindfulness induction delivered in a laboratory setting on measures of self-regulation. Twenty-seven studies were included and grouped according to 3 outcomes: regulation of experimentally induced negative affect ($k = 15$; meta-analysis), emotion-regulation strategies ($k = 7$) and executive functions ($k = 9$; narrative synthesis). A mindfulness induction was superior to comparison groups in enhancing the regulation of negative affect ($d = –.28$). Executive-function performance was enhanced only when the experimental design included an affect induction or when the outcome was sustained attention. The effect on emotion-regulation strategies was inconclusive, but with emerging evidence for an effect on rumination. Overall, the findings indicate that, in the form of an induction, mindfulness may have the most immediate effect on attention mechanisms rather than exerting cognitive changes in other domains, as are often reported outcomes of longer mindfulness training. Through effecting change in attention, emotion regulation of negative affect can be enhanced, and subsequently, executive-function performance more quickly restored. The interpretations of the findings are caveated with consideration of the low quality of many of the included study designs determined by the quality appraisal tool.

*Keywords:* mindfulness, induction, self-regulation, meta-analysis, experimental



Self-regulation is the regulation of affect, cognitions, or behaviors in accord with goal-directed behavior (Karoly, 1993). Self-regulation has been considered to encompass three main components. The first is the endorsement of particular standards of thought, feeling, or behavior that are mentally represented and monitored. The second component is the motivation to reduce discrepancies between standards and real states. The third component is sufficient capacity to reduce the discrepancy, despite encountering barriers and temptations (Baumeister & Heatherton, 1996; Carver & Scheier, 2012). Failures in self-regulation can occur in any of these three areas and all are considered to be necessary to enable successful self-regulation. Difficulties with self-regulation are symptomatic of many clinical conditions, such as impulsivity in attention-deficit/hyperactivity disorder (Barkley, 2010) or rumination in depression (Aldao, Nolen-Hoeksema, & Schweizer, 2010). However, problems with self-regulation are also common in nonclinical populations and are negatively associated with physical health, management of personal finances, and criminal offenses (Moffitt et al., 2011). Self-regulation is a complex function relying on multiple cognitive and affective systems, and effective symbiosis between these systems, most pertinently, executive functions (EFs) and emotion regulation. The discussion of self-regulation is therefore presented here with consideration of these two related mechanisms.

Some of the proposed mechanisms underpinning self-regulation are EFs, which have been widely accepted by researchers as consisting of working memory, inhibitory control of prepotent impulses, and mental set-shifting (Miyake et al., 2000). A bidirectional model of EFs and self-regulation has been proposed that presents the constructs as operating in an interactive feedback loop (Blair & Ursache, 2011). Within this model, EFs are primary mechanisms for self-regulation, particularly impacting on and interacting with attention and emotion systems. Through this, EFs facilitate self-regulation by directing attention and emotion systems, while also depending on bottom-up nonexecutive regulation of attention and emotion to effectively operate (Blair & Ursache, 2011). Factors such as stress, intoxication and negative affect can impair EFs and consequently cause self-regulation failures (see Hofmann, Schmeichel, & Baddeley, 2012; Wagner & Heatherton, 2014). As an exemple, negative affect can disrupt self-regulatory processes by interfering with each stage of self-regulation: amplifying desires, decreasing monitoring, depleting limited capacity, and encouraging incorrect use of regulation strategies (Wagner & Heatherton, 2014). If not effectively regulated, negative affect may even lead to self-regulation failure, such that behaviors are enacted that are not in line with long-term goals and a state of negative affect persists.

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The self-regulation of emotion, or emotion regulation, is broadly defined as any effort that is made to modulate emotional experiences (Gross, 2002). Situations can give rise to affective responses, both with primary, immediate, raw emotional responses and a secondary regulated response (Lazarus, 1991). The temporality between these two phases of response can vary, as can the regulatory strategy. The process model of emotion regulation identifies four stages of emotion generation (Gross, 1998, 2001): the emotive situation, the deployment of attention, cognitive appraisals, and emotion expression. Each stage has the potential to give rise to emotions and be the target for different emotion-regulation strategies. The strategies for emotion regulation include modification or selection of the situation, attention deployment away from emotive stimuli, changing the cognitions relating to the situation, and response modulation. It has been proposed that engaging in emotion-regulation strategies earlier in the process is more cognitively efficient and effective (Gross, 2001) than later. For example, exiting the emotive situation (situation selection) uses fewer cognitive resources and is more effective than altering the cognitive appraisals of the emotive situation (cognitive change).

To support goal pursuit, the feedback model of emotion and behavior denotes that the primary mechanism of most emotions is to inform cognition, which can, in turn, elicit behaviors or behavior changes (Baumeister, Vohs, DeWall, & Zhang, 2007). In some cases, behavior may be directly guided by reflexes (e.g., flight or fight) or highly charged emotions. These reflexes, such as an urge to flee a situation, can impair EFs and result in impulsive behaviors. These impulsive actions may not be in line with long-term goals. Emotions are considered far more challenging to regulate than cognitions or behaviors and they often require the most complex interventions and strategies to elicit change (Baumeister et al., 2007; Baumeister, Heatherton, & Tice, 1994).

## Mindfulness and Self-Regulation: Theoretical Models

Mindfulness meditation is often described as nonjudgmental attention and acceptance of present-moment experience (Brown & Ryan, 2004). Several theoretical models include self-regulation as a proposed change mechanism in mindfulness training. Tang, Hölzel, and Posner (2015) suggest that mindfulness meditation exerts effects through emotion regulation, attention control and self-awareness. These three components work together to generate enhanced self-regulation. Mindfulness may serve as a tool for emotion regulation by increasing reperceiving of experience, also referred to as mindful reappraisal or decentering. As a metacognitive function, reperceiving requires a process of stepping back from an experience to more clearly assess it (Garland, Gaylord, & Park, 2009). Within the process model of emotion regulation, these are examples of cognitive change strategies of emotion regulation that occur as appraisals of emotions are altered (Gross, 2001). Attention control or attention regulation pertains to the ability to sustain attention on a chosen object and to redirect attention back to the object when there are distractions (Hölzel et al., 2011). Mindfulness practices often include a focus of attention, such as the breath, and instructions to return attention to the breath when it inevitably moves to other internal or external foci. The cultivation of attention control in this way is considered a foundation for later meditative practices (Hölzel et al., 2011). The process model of emotion regulation asserts that attention redeployment is an emotion-regulation strategy and is more cognitively efficient than processes of cognitive change (Gross, 2001). The redeployment of attention can be both volitional and automatic (Posner & Petersen, 1990). Mindfulness training supports volitional control of attention toward a selected object, such as the breath. Ultimately, a goal of mindfulness training may be to increase awareness and ability to attend to emotions, cognitions, and physical sensations, even when these experiences are highly emotionally charged. Counterintuitively, the volitional control of attention toward a chosen object but away from the emotionally charged experience, for example, toward the breath and away from feelings of sadness, may support increased awareness of and attention to the difficult experience. This temporary redeployment of attention away from the emotive experience may reduce the intensity of the emotionally charged experience and lessen the likelihood that a habitual behavioral reaction will be enacted. As a result, effective reappraisal strategies, such as decentering, can be more readily employed (Shapiro, Carlson, Astin, & Freedman, 2006). Mindfulness may enhance self-awareness, as mindfulness training promotes greater observation of internal experiences such as of the senses, breath, and emotions (Hölzel et al., 2011).

The self-awareness, self-regulation, and self-transcendence framework (S-ART) also provides a model for understanding the mechanisms of mindfulness (Vago & Silbersweig, 2012). The S-ART framework views mindfulness as a training method to reduce self-specific biases through development in three areas. The first two areas are the enhancement of meta-awareness (self-awareness) and the effective management or alteration of impulses and behavioral responses (self-regulation). The final area is the development of a more positive relationship between the self and the environment that extends beyond mere selfish needs (self-transcendence). Furthermore, the S-ART framework proposes that mindfulness exerts change on these three domains via specific mechanisms of action: intention and motivation, attention regulation, emotion regulation, memory, prosociality, and nonattachment or decentering.

An alternative model comprises three axioms of mindfulness: intention (reason underpinning choice to practice mindfulness), attention (observation of moment-to-moment experience), and attitude (acceptance, kindness, and openness). These three axioms underpin a metamechanism of "reperceiving," which then gives rise to several mechanisms of change, including self-regulation (Shapiro et al., 2006). Similarly, the three mechanisms of mindfulness (emotion regulation, attention control, and self-awareness) proposed by Tang and colleagues (2015) are all underpinned by the attitude and intention brought to an individual's mindfulness practice. These axioms determine the spirit with which an individual pays attention and motivates him or her to practice mindfulness (Shapiro et al., 2006).

## Mindfulness Interventions and Inductions

Mindfulness-based interventions (MBIs) are typically formed of 8 weeks of mindfulness training, which encompasses experiential exercises (e.g., mindfulness of breathing, body scan), group discussions, home practices, and psychoeducation relating to mindfulness theory and research. This typical group-based training format originates from two of the most influential mindfulness-training models: mindfulness-based stress reduction (MBSR; Kabat-

Zinn, 1990) and mindfulness-based cognitive therapy (MBCT; Williams, Teasdale, Segal, & Kabat-Zinn, 2007). Systematic reviews of the evidence identify significant positive effects of MBIs on emotion regulation (e.g., Eberth & Sedlmeier, 2012; Gu, Strauss, Bond, & Cavanagh, 2015) and mixed evidence for significant positive effects on EFs (e.g., Chiesa, Calati, & Serretti, 2011; Lao, Kissane, & Meadows, 2016). Although a review by Gu and colleagues (2015) reported on the theoretical support for self-regulation as a mediating mechanism of mindfulness intervention, they found no randomized controlled trials or quasi-experimental studies that had tested this assertion. There is, therefore, more support for direct effects of mindfulness interventions on cognitive and affective aspects of self-regulation than viewing self-regulation as a mediating mechanism of mindfulness.

There is growing experimental interest in the potential utility of mindfulness as a one-time novel practice, referred to here as a mindfulness induction. A mindfulness induction is an experiential mindfulness practice that may form part of an MBI program, for example, mindfulness of breathing, loving kindness, and acceptance practices. As an exemplar of a mindfulness induction, Arch and Craske (2006) used a 15-min guided practice focusing attention on present-moment sensations, including the breath, before assessing emotion regulation. A mindfulness induction used in an experimental design allows for more control over the nature and dosage of the exposure and its comparator. Consequently, more robust casual inferences can be drawn (Keng, Smoski, & Robins, 2011; Tang et al., 2015). Mindfulness inductions differ in many ways from MBIs, as they are standalone experiential practices delivered without broader instruction on mindfulness theory or education. In comparison, MBIs have multiple sessions and include broader training, group discussion, and homework practices. In addition, the formation of MBIs are supported by guidelines regarding their necessary constituents (Crane et al., 2017), whereas mindfulness inductions have no agreed form for their content, delivery mode, or duration. As a result, the format and delivery of each mindfulness induction is variable across published papers. In a narrative review of the literature, Keng et al. (2011) concluded that a mindfulness induction could lead to immediate benefits, particularly for recovery from dysphoria and reducing emotional reactivity to aversive stimuli. A mindfulness induction was also shown to increase decentering (Mahmood, Hopthrow, & Randsley de Moura, 2016; Lebois et al., 2015), reduce thought suppression (Brunyé et al., 2013), and aid recovery from negative mood (e.g., stress, Steffen & Larson, 2015; low mood, Huffziger & Kuehner, 2009). Similarly, a mindfulness induction has been shown to improve executive attention (Kuo & Yeh, 2015; Gorman & Green, 2016). In a review of neurobiological evidence, three studies (comparing mindfulness-induction with no-control cognitive reappraisal and no instruction) measuring functional magnetic resonance imagery provided evidence of both top-down and bottom-up emotion-regulation effects (Guendelman, Medeiros, & Rampes, 2017). This evidence contradicts some previous conclusions that naïve meditators employ only top-down regulatory strategies (Chiesa, Serretti, & Jakobsen, 2013). The extent to which preexisting theoretical models of mindfulness explain the empirical effects of a mindfulness induction has not been explored in the literature, nor have alternative theories been proposed.

Currently, there is promise for a direct effect of a mindfulness induction on self-regulation. However, a comprehensive review of empirical investigations of the effects of a mindfulness induction on self-regulation across multiple disciplines is necessary to estimate the presence or strength of an effect. In a nonclinical population, self-regulation can be more precisely considered, one reason for which is that the presentation of self-regulation difficulties in nonclinical populations is more homogenous than, and does not interact with, other aspects of a complex clinical presentation. Therefore, as the initial attempt to consolidate evidence in this field, this review is focused on self-regulation in a nonclinical population, which can broaden our understanding of the theories and mechanisms of mindfulness, and then be applied to more complex and specific presentations of self-regulation as they appear in each clinical group.

Self-regulation is a broad term that encompasses cognitive, affective, behavioral, physiological, and neurological areas of functioning. Such multiplicity is reflected in the use of diverse empirical measures and nomenclature denoting the term. This review focuses on the affective and cognitive domains of self-regulation as measured using behavioral and self-report means, and spotlights the evidence corresponding with the dominant theories of self-regulation, in particular, the critical and intertwined role of emotions and cognitions in facilitating or precluding self-regulation and goal pursuit. In addition, there is empirical support for the affective and cognitive aspects of self-regulation as a target for mindfulness training, as well as theoretical evidence of self-regulation as a possible mechanism of mindfulness.

Specifically, our review reports on emotion regulation and EFs, as these emerged as appropriate subgroups for the outcomes of the articles that met the inclusion criteria. We measured emotion regulation in two ways: (a) the regulation of experimentally induced negative affect and (b) changes to regulatory strategies (e.g., rumination, decentering). EFs include three constructs: Updating, Set-Shifting and Inhibitory Control (Miyake et al., 2000). Measures pertaining to the EF outcome have been grouped accordingly; thus, the results are presented pertaining to three areas: the regulation of experimentally induced negative affect (meta-analysis), emotion-regulation strategies, and EFs (narrative synthesis). Based on the theoretical and empirical links between mindfulness and self-regulation, we aimed to explore whether a mindfulness induction could enhance self-regulation relative to alternative inductions.

## Method

### Search Strategy

We searched major psychological and related databases (i.e., PsycINFO, PsychARTICLES, MEDLINE, Web of Science, and ProQuest Dissertation & Theses) using descriptors for the three key search areas: mindfulness meditation ("mindfulness*," "loving kindness," "mindful," "body scan," or "focused attention"); experimental laboratory design ("experimental" or "laboratory"); and brief mindfulness induction ("brief," "induction," "instruction," "short," "single," or "one"). Database tools were used to identify truncations or alternative spellings of terms (e.g., "mindful*"). Forward and backward citation searches were conducted for key reviews (Keng et al., 2011; Williams, 2010; Webb, Miles, & Sheeran, 2012; Levin, Hildebrandt, Lillis, & Hayes, 2012) and all articles meeting inclusion criteria. Finally, the journal *Mindfulness*

was hand-searched. Where relevant dissertations or theses were identified, a targeted search was conducted for published content. Searches concluded May 2017.

## Selection Criteria

A flowchart of the study-selection process is shown in Figure 1. Qualifying studies fulfilled five selection criteria: (a) Having an experimental design in which participants were allocated to a mindfulness induction or comparison group and all data were collected in one session—designs incorporating additional experimental inductions (e.g., negative affect, rumination) were included except where both inductions were delivered concurrently, as this mode of delivery constitutes a different form of mindfulness practice; (b) mindfulness induction was defined as a practice derived from one of the core experiential components of MBIs (e.g., mindfulness of breathing, body scan), with a single practice completed in one experimental session; (c) participants were drawn from general nonclinical populations, papers were excluded where a specific sub-group of non-clinical participants were described, e.g. heavy drinkers, or those with elevated levels of depression—data collection occurred independently (e.g., not through group interactions) and the majority of the participant sample had no previous meditation experience; (d) outcomes were behavioral or self-report measures of self-regulation, including regulation of negative affect (e.g., affect measure before-after induction), emotion-regulation strategies (e.g., self-report use of a regulation strategy), and EFs; and (e) status of publication included peer-reviewed publications written in English.

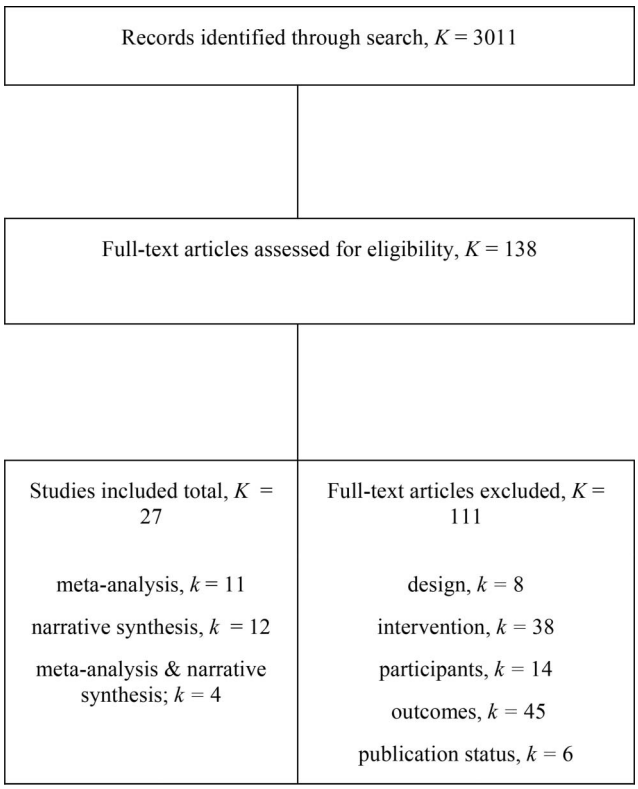


*Figure 1.* Flow chart of study inclusion and exclusion process.

The papers included in the three outcome groups (i.e., regulation of negative affect, emotion-regulation strategies, and EFs), were considered with regard for their methodological similarity, (e.g., the outcome measures, order of induction, and inclusion of additional experimental induction). Only one outcome group, the regulation of negative affect, was considered sufficiently, methodologically homogenous for meta-analysis. Additional criteria only applied to papers included in the meta-analysis were (a) randomization to experimental group, (b) induction of negative affect (e.g., sadness, anger), and (c) the subsequent measurement of negative affect as an indicator of emotion regulation. Outcome data from one study could be included in more than one outcome subgroup, and when the subgroup was analyzed narratively, more than one outcome measure could be included in the analysis. A list of excluded studies and the rationale for exclusion can be obtained from the first author upon request.

## Quality Appraisal

The quality of included papers was assessed using the Effective Public Health Practice Project (EPHPP) tool for quantitative studies (EPHPP, 2009), which is appropriate for use on cross-sectional, case-control design studies. The EPHPP tool consists of 15 questions across six components: selection bias, study design, confounders, blinding, data-collection methods, withdrawals, and dropouts). A rating for each component and overall quality was made as follows: strong (overall no weak components), moderate (overall one weak component), or weak (overall two or more weak components). The withdrawals and drop-out items of the EPHPP were adapted to include participant data that had been excluded for any reason (e.g., technical error) to accurately capture the number of participants whose data were collected in part or in full, but subsequently not analyzed. The quality of the included studies was assessed by a second researcher with an agreement of $\kappa = .82$; discrepancies, mostly regarding the application of the validity and reliability items, were resolved through discussion.

## Data Extraction

The following data were extracted for each study: publication details, study design, details of mindfulness induction, participant details, induction-manipulation measure (e.g., state mindfulness, negative affect), and details about the primary outcome measures used. Descriptions of comparison-group activities were coded by the first author and a postgraduate researcher into five categories: distraction (activity not related to self-directed thoughts, e.g., reading), mind wandering (instruction to think freely), maladaptive regulation (instruction to have self-directed thoughts, worries, or suppress thoughts), alternative adaptive regulation (instructions informed by other therapeutic techniques known to alter affect, such as reappraisal), and no instruction (no activity, waiting). Agreement between coders was $\kappa = .85$, with discrepancies resolved through discussion.

Only one outcome was included from each paper in the meta-analysis: regulation of negative affect. In studies in which there was more than one comparison group, the comparator was the least active in the following order: no instruction, distraction, mind wandering, alternative adaptive regulation, and maladaptive regulation. For the remaining outcomes (i.e., emotion-regulation strat-

egies, EFs), all relevant data were extracted. Data from Stroop tests (Stroop, 1935) and the flanker task (Eriksen & Eriksen, 1974) were entered as interference scores, calculated by dividing the differences in latencies in reaction times or error rates of incongruent and congruent trials by the total latencies or error rates for both trial types.

## Calculation of Effect Sizes

Standardized mean differences (*SMD*s) were calculated based on means and standard deviations as the measure of effect sizes for all relevant data for the three outcomes. Where available, the pretest standard deviation was used, because it has no effect of experimental manipulation, is a more consistent estimate of variance between groups (Becker, 1988). In cases in which insufficient data were reported ($k = 10$), corresponding authors were contacted to obtain access to data, and in such cases ($k = 3$), either test statistics were used to calculate effect sizes ($k = 1$) or the findings were presented as a narrative summary only ($k = 2$). SMDs were calculated comparing the mindfulness induction group with each comparison group separately. A meta-analysis pooled the effects of a mindfulness induction on the regulation of negative affect using a random-effects model. The random-effects model assumes that each effect-size distribution interacts with the between-study variance component ($\tau^2$, Hedges & Vevea, 1998). This approach allows for broader generalization of the findings (Field, 2005) and reduces the Type I error rate inflated by the fixed-effects model (Hunter & Schmidt, 2000). The meta-analysis was conducted in Review Manager 5, with the analytical process informed by Deeks and Higgins (2010).

## Heterogeneity and Publication Bias

For meta-analytic data, heterogeneity of effect sizes was determined using the $Q$ statistic and $I^2$ values. $Q$ tests the hypothesis that variance of the effect sizes is no different than would be expected as a result of sampling error alone. $I^2$ was calculated as an indicator of the proportion of heterogeneity among the studies beyond that which may be expected by chance (Higgins & Thompson, 2002; Higgins, Thompson, Deeks, & Altman, 2003). $I^2$ values of 25, 50, and 75 were considered low, moderate, and high, respectively (Higgins & Thompson, 2002).

Publication bias can result in overrepresentation of significant findings in published papers (Rothstein, Sutton, & Borenstein, 2005), and for this review, we assessed the effect of publication bias visually on a funnel plot (Egger, Smith, Schneider, & Minder, 1997) and through calculation of Rosenthal's (1979) fail-safe *N*. The funnel plot represents the distribution of study-effect sizes against the standard error of effects. In the current sample, we identified bias by a missing right-hand tail of an inverted funnel shape. In the event of visual identification of bias, a "trim and fill" method is required to identify the additional number of published studies, favoring the comparison induction, required to eliminate the potential effect of any publication bias (Duval & Tweedie, 2000). The fail-safe *N* indicates the number of missing studies that had a mean effect of zero, and that would need to be added to the group of existing studies before their combined effect was no longer statistically significant.

# Results

Twenty-seven studies met inclusion criteria (see Figure 1), but only a subset of included articles was deemed suitably methodologically homogenous to be entered into a meta-analysis. Fifteen papers reporting effects on the regulation of negative affect following an emotion induction were sufficiently similar in design to be pooled in a meta-analysis. The remaining two groups were synthesized narratively for outcomes pertaining to emotion-regulation strategies ($k = 7$) and EFs ($k = 9$; Figure 1). These papers were methodologically heterogeneous in terms of the variation of the outcome measured, including differences in the target construct (e.g., Inhibition, Updating, Set-Shifting as subcomponents of EF) and means of assessment (e.g., Stroop test, digit span). In addition, a subset of these papers included other experimental manipulations (e.g., affect induction; $k = 19$; see Table 1).

## Quality

Overall, the quality of the included papers was rated as weak in both the meta-analysis ($k = 11$) and the narrative synthesis ($k = 14$; Table 1) based on the criteria of the EPHPP appraisal tool. The areas of weakness particularly related to the generalizability of the samples, because most were from undergraduate populations ($k = 26$), failed to report on or use valid and reliable outcome measures ($k = 20$), or failed to report or reported unclear exclusions of data ($k = 10$). Also, despite the experimental methodology lending itself well to a double-blind procedure, explicit reports of blinding of experimenters ($k = 3$) or participants ($k = 4$) were rare, and consequently, the papers scored lower on this component.

## Mindfulness Induction

A design overview and summary of mindfulness inductions of the 27 included papers is presented in Table 1. The majority of mindfulness inductions referred to a focal object ($k = 22$) such as the breath, senses, or food. The majority of mindfulness inductions included instructions to be aware of the breath or body ($k = 24$), focus attention ($k = 14$), and accept the experience ($k = 16$). A small proportion of papers included full scripts of the inductions in text or as supplementary materials ($k = 5$). The average duration of mindfulness induction was 10 min ($SD = 3$ min; range = 5–25 min). There were 39 comparison inductions described across the papers, with 12 papers reporting two comparators. The most frequently used comparison group was distraction ($n = 17$), followed by no instruction ($n = 6$), alternative adaptive regulation (e.g., reappraisal; $n = 6$), mind wandering ($n = 5$), and maladaptive regulation (e.g., thought suppression; $n = 5$).

## Mindfulness Induction and the Regulation of Negative Affect

The meta-analysis included data from 15 peer-reviewed studies (see Table 1), generating 15 effect sizes between $d = -0.80$ and 0.46 (see Figure 2). Twelve effect sizes were not significant, with the remaining three favoring a mindfulness induction (Long & Christian, 2015; Kiken & Shook, 2014; Villa & Hilt, 2014). The weighted mean effect of a mindfulness induction on regulation of negative affect was $SMD_{\text{weighted}} = -0.28$, 95% CI = [−0.44, −0.11], $z = 3.24$, $p = .001$, confirming that a mindfulness induction regulated

Table 1
*Overview of Study Characteristics Across All Included studies, Including Descriptions of Mindfulness and Comparison Inductions*

| Author (year) country | Study design/procedure/ randomized | *N* (attrition) | Quality | Mindfulness induction components | | | | | | Mindfulness induction duration (mins)/descriptor/ script/origin | Comparison induction(s)/ manipulation check | Experimental Induction (EXI) method/inducing/ manipulation check/measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Focus attention | Regulate attention | Aware present moment | Aware breath/ body | Aware thoughts/ emotions | Attitude | | | |
| Arch & Craske (2006) USA | POST; EXI-MF-EXI-EXI; R | 60 (–) | WK | X | | X | X | | | 15; Ind; exerts; KZ + SEG | MW MAL; Y | Images; NA; Y; PANAS |
| Bing-Canar, Pizzuto, & Compton (2016) USA | POST; NR | 44 (7) | WK | X | | X | X | | | 15; Exe; No; KZ + LARS | DIS; No | — |
| Broderick (2005) USA | PRE-POST; EXI-MF; R | 209 (32) | MOD | | | | X | | X | 8; Cond; No; KZ | DIS; Y | Statements + music; sad; Y; PANAS |
| Carlin & Ahrens (2014) USA | POST; MF-EXI; R | 100 (–) | WK | X | | | X | | | 15; Ind; No; ARCH + KZ | MW; No | Film; fear; Y; math test |
| Long & Christian (2015) USA | PRE-POST; MF-EXI; R | 117 (8) | WK | X | | X | X | | X | 12; Man; exerts; KIKE | NOIN; No | Feedback; inj; Y; PANAS |
| Erisman & Roemer (2010) USA | PRE-POST; EXI-MF; R | 33 (3) | WK | X | | | X | X | X | 10; Exp; full; SEG | DIS; No | Film; sad; Y; PANAS |
| Feldman, Greeson, & Senville (2010) USA | POST; R | 190 (–)[a] | WK | | X | | X | | X | 15; None; No; SEG + ARCH | AAR AAR; Y | — |
| Heppner et al. (2008) USA | POST; MF-EXI; R | 60 (3) | WK | X | | | X | | | 6; Ind; full; KZ | NOIN; No | Peer feedback; ang; No; noise blast |
| Hilt & Pollak (2012) USA | PRE-POST; EXI-MF; R | 102 (6)[b] | MOD | | | X | X | X | X | 8; Int; exert; BROD | AAR DIS; No | Feedback + Rum; NA + Rum; Y; PANAS |
| Hooper, Villatte, Neofotistou, & McHugh (2010) UK | PRE-POST; EXI-MF; NR | 50 (26) | WK | X | | | | | | 10; Ind; No; ARCH | MAL; Y | Images; NA; No; IRAP + AAQ |
| Johnson, Gur, David, & Currier (2015) USA | PRE-POST; R | 92 (–) | WK | X | | | X | X | X | 25; SS; Full; ZEID | AAR DIS; Y | — |
| Keng, Robins, Smoski, Dagenbach, & Leary (2013) USA | PRE-POST; MF-EXI; R | 125 (29) | WK | | | X | X | X | X | 10; Cond; SUP; SING | AAR NOIN; Y | Recall event + music; SAD; Y; VAS |
| Keng, Tan, Eisenlohr-Moul, & Smoski (2017) SIN | PRE-POST; MF-EXI; R | 171 (46) | WK | | | | | X | X | 10; Cond; No; SING | AAR MAL; Y | Recall event + music; sad; Y; VAS |
| Kiken & Shook (2014) USA | POST; MF-EXI; R | 102 (–) | WK | X | X | X | X | X | X | 10; Ind; No; ARCH + KIKE | MW; No | Thought list + music; sad; Y; VAS |
| Kuehner, Huffziger, & Liebsch (2009) GER | PRE-POST; EXI-MF; R | 60 (–) | WK | | | X | X | X | X | 8; Con; exerts; SEG + HEID + SING | DIS MAL; No | Event recall + music; sad; Y; PANAS |
| Larson, Steffen, & Primosch, (2013) USA | POST; R | 62 (7) | WK | X | | X | X | | | 14; Int; No; KZ2 | DIS; No | — |
| McHugh, Procter, Herzog, Schock, & Reed (2012) UK | POST; R | 19 (–) 30 (–) | WK | X | X | | X | | | 15; Ind; full; none | MW; No | — |
| Molet, Macquet, Lefebvre, & Williams (2013) FRA | POST; MF-EXI; R | 48 (–) | WK | X | | X | X | | | 12; Ind; No; MCH | MW; Y | Computer game; Ost; Y; Affect Scale |
| Mrazek, Smallwood, & Schooler (2012) USA | POST[c]; R | 60 (–) | WK | X | | | X | X | X | 8; Task; No; None | DIS NOIN; No | — |
| Ortner & Zelazo (2012) CAN | PRE-POST; EXI-MF; R | 52 (–) | WK | X | X | X | X | X | X | 10; Man; No; SEG | DIS NOIN; Y | Event recall; Ang; Y; PANAS |
| Remmers, Topolinski, & Koole (2016) GER | PRE-POST; EXI-MF; R | 78 (6) | MOD | | | X | | | X | 5; Ind; No; HUF | DIS RUM; No | Event recall + music + statements; Sad; Y; IPANAT |

(*table continues*)

Table 1 (*continued*)

| Author (year) country | Study design/procedure/ randomized | *N* (attrition) | Quality | Mindfulness induction components | | | | | | Mindfulness induction duration (mins)/descriptor/ script/origin | Comparison induction(s)/ manipulation check | Experimental Induction (EXI) method/inducing/ manipulation check/measure |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Focus attention | Regulate attention | Aware present moment | Aware breath/ body | Aware thoughts/ emotions | Attitude | | | |
| Reynolds, Lin, Zhou, & Consedine (2015) NZ | PRE-POST; MF-EXI; R | 104 (3) | MOD | | | | X | X | | 10; Ind; No; ERIS | DIS; Y | Smell; Dis; Y; DES |
| Villa & Hilt (2014) USA | PRE-POST; EXI-MF; R | 114 (3) | WK | X | | X | X | X | X | 8; Int; No; BROD | DIS NOIN; No | Event recall + music + rum; NA + rum; Y; PANAS |
| Watford & Stafford (2015) USA | POST; MF-EXI; R | 70 (–)[d] | MOD | | | | X | X | | 15; Int; No; ERIS + KZ | DIS; Y | Images + sounds; NA; Y; PANAS |
| Watier & Dubois (2016) CAN | POST; R | 78 (6) | WK | | | X | X | X | | 10; SS; No; ERIS | DIS DIS; Y | — |
| Weger, Hooper, Meier, & Hopthrow (2012) UK | PRE-POST; MF-EXI; R | 71 (–) | WK | X | | | X | X | | 15; Int; No; HEPP | DIS; No | Task instruction; Ste Thr; Y; Math test |
| Yusainy & Lawrence (2015) UK | PRE-POST; R | 110 (8)[e] | WK | X | X | | X | | X | 15; Ind; No; WILL + KRA | DIS; No | — |

*Note*. SIN = Singapore; GER = Germany; FRA = France; CAN = Canada; NZ = New Zealand; *N* = whole sample; MF = mindfulness induction; EXI = experimental induction; R = randomized; NR = not randomized; WK = weak; MOD = moderate; Ind = induction; Exe = exercise; Cond = condition; Man = manipulation; Exp = experimental; Int = intervention; SS = single session; KZ = Kabat-Zinn (1990); SEG = Segal (2002); LARS = Larson et al. (2013); ARCH = Arch and Craske (2006); KIKE = Kiken and Shook (2011); BROD = Broderick (2005); ZEID = Zeidan, Johnson, Diamond, David, and Goolkasian (2010); SING = Singer and Dobson (2007); HEID = Heidenreich and Michalak (2003); KZ2 = Kabat-Zinn (2006); MCH = McHugh et al. (2012); HUF = Huffziger and Kuehner (2009) ERIS = Erisman and Roemer (2010); HEPP = Heppner et al. (2008); WILL = Williams and Penman (2011); KRA = Kramer, Weger, and Sharma (2013); SUP = supplementary online material; MW = mind wandering; MAL = maladaptive alternative regulation; Y = yes; DIS = distraction; NOIN = no instruction; AAR = alternative adaptive regulation; NA = negative affect; PANAS = Positive and Negative Affect Schedule; Sad = sadness; Inj = injustice; Ang = anger; Rum = rumination; VAS = visual analogue scale; Ost = ostracism; IPANAT = Implicit Positive Affect and Negative Affect Test; DES = Differential Emotion Scale; Ste thr = stereotype threat.
Participant attrition rates were averaged where exclusion rates differed between statistical tests within a single sample.
[a] All participants female. [b] Participants 9–14 years old. [c] Sustained-attention-to-response-task practice trials took place pre-induction. [d] Both negative and positive affect were manipulated experimentally; only data from negative affect induction are presented here. [e] A self-control depletion activity was administered to some participants; data for those participating in the depletion activity were excluded from this review.

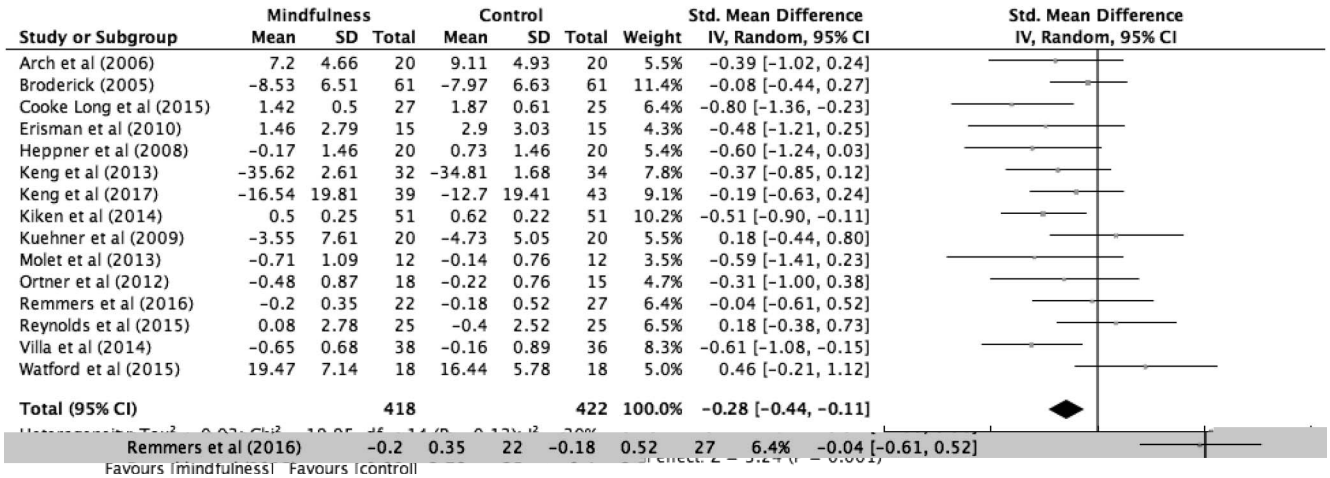


*Figure 2.* Forest plot of weighted standardized mean differences and a pooled measure of effect of induction on regulation of negative affect. In cases in which a study design had two comparison groups, the least active was entered as the comparison group.

negative affect more effectively than the comparison inductions (e.g., mind wandering, distraction). There was low–moderate heterogeneity (30%) for included studies based on the $I^2$ statistic (Higgins & Thompson, 2002), with a nonsignificant $Q$ statistic indicating low statistical differences between included studies. The funnel-plot tails appeared balanced and the fail-safe $N$ (i.e., number of unpublished papers required to change the $z$ value to nonsignificant) was $k = 879$, which was greater than the estimated 85 unpublished studies.

Seven subgroup analyses were conducted to assess the effect of methodological differences between study designs on the pooled estimates of effect (see Table 2). There was no significant difference between mindfulness and distraction on the regulation of negative affect, whereas mindfulness was superior

Table 2
*Effect Sizes for Overall and Subgroup Meta-Analysis of Effect of Induction on Regulation of Negative Affect*

| Overall effect or methodological subgroup | *k* | MF *n* | CT *n* | SMD | LCI | UCI |
|---|---|---|---|---|---|---|
| Overall effect | 15 | 418 | 422 | **−.28** | **−.44** | **−.11** |
| Comparison group[a] | | | | | | |
| Distraction | 8 | 142 | 227 | −.01 | −.22 | .21 |
| Mind wandering | 4 | 100 | 108 | **−.58** | **−.86** | **−.30** |
| Maladaptive regulation | 5 | 81 | 138 | **−.38** | **−.65** | **−.11** |
| No instruction | 4 | 64 | 105 | **−.50** | **−.82** | **−.18** |
| Emotion-induction specificity | | | | | | |
| Specific emotion | 11 | 291 | 297 | **−.24** | **−.42** | **−.06** |
| General negative affect | 4 | 127 | 125 | −.32 | −.73 | .10 |
| Emotion-induction personal relevance | | | | | | |
| High | 8 | 215 | 220 | **−.35** | **−.57** | **−.14** |
| Low | 7 | 202 | 202 | −.19 | −.46 | .08 |
| Induction order[b] | | | | | | |
| Emotion: mindfulness | 6 | 174 | 174 | −.22 | −.45 | .02 |
| Mindfulness: emotion | 8 | 209 | 209 | **−.30** | **−.58** | **−.02** |
| Mindfulness-induction duration[c] | | | | | | |
| 5–15 min | 15 | 418 | 422 | −.03 | −.09 | .03 |
| Design | | | | | | |
| Post test | 5 | 121 | 121 | −.34 | −.70 | .02 |
| Pre-post test | 10 | 297 | 301 | **−.26** | **−.44** | **−.05** |
| Outcome measure | | | | | | |
| PANAS | 8 | 217 | 210 | −.26 | −.54 | .02 |
| Other | 7 | 200 | 212 | **−.29** | **−.50** | **−.09** |

*Note.* $k$ = number of studies in subgroup; MF = mindfulness; CT = comparison group; $n$ = number of participants in induction group; SMD = standardized mean difference; LCI = lower confidence interval; UCI = upper confidence interval. Significant effect sizes are in boldface.
[a] Where mindfulness group was used as comparator against more than one comparison group, the mindfulness group $n$ was divided by the number of times the data was entered in the analysis; alternative adaptive regulation not entered as a subgroup analysis, as the subgroup contained data from only two studies. [b] Arch et al. (2006) was not entered, as emotion inductions were repeated more than once. [c] Metaregression of induction length calculated on Comprehensive Meta-Analysis Software Version 3; the value denoted under the heading SMD represents the regression coefficient.

to all other comparison inductions in reducing negative affect. There was only a significant effect of mindfulness on negative affect in cases in which (a) the emotion induction targeted a specific emotion (e.g., sadness) rather than general negative affect, (b) the mindfulness induction preceded the emotion induction, and (c) the method of emotion induction was more personally relevant (e.g., recall of personal event). Effect sizes were only significant when pre–posttest designs were used and affect was measured using means other than the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988; e.g., visual analogue scales of state affect). The effect of order of delivery of the mindfulness and emotion inductions may mean that the mindfulness induction acted to prime participants to process the emotion induction differently than those who practiced mindfulness after the emotion induction. A metaregression of duration of mindfulness induction (range = 5–15 min) did not reveal any effect of induction length and there was no association between duration of mindfulness induction and effect-size strength $r = .03$, $p = .919$.

## Mindfulness Induction and Emotion-Regulation Strategies

Seven articles reported the effect of mindfulness induction on emotion-regulation strategies, generating 11 effect sizes (see Table 3). The experimental aim was for a mindfulness induction to increase adaptive emotion-regulation strategies (e.g., decentering) or reduce maladaptive regulation strategies (e.g., rumination, experiential avoidance) more than comparison inductions. Four effects (40%) demonstrated a significant effect of the mindfulness induction compared to comparison inductions, with effect sizes ranging from .40 to −2.09, (Long & Christian, 2015; Feldman, Greeson, & Senville, 2010; Villa & Hilt, 2014). Three of the significant effects were for measures of rumination ($k = 5$ measuring rumination), demonstrating a significant effect of a mindfulness induction to reduce rumination when compared with mind wandering and no-instruction comparison groups. In contrast, the effect was not conclusive when compared with other adaptive regulation instructions (e.g., problem solving) and was equal to the effects of distraction.

## Mindfulness Induction and EFs

Nine studies reported the effect of a mindfulness induction on EFs (see Table 4), with seven studies having sufficient detail to generate 25 effect sizes. Outcome measures reflected Miyake et al.'s (2000) classification of EFs: Updating (including working memory), Set-Shifting and Inhibitory Control. Three studies used an additional experimental induction of sadness (Keng, Robins, Smoski, Dagenbach, & Leary, 2013; Keng, Tan, Eisenlohr-Moul, & Smoski, 2017) or stereotype threat (Weger, Hooper, Meier, & Hopthrow, 2012), either before or after a mindfulness induction. Overall, eight effect sizes (32%) originating from four studies were significant, with seven of these measuring Inhibition (58% of total measuring inhibition). The majority of the significant effects were reported by Mrazek, Smallwood, and Schooler (2012), who measured executive attention using the Sustained Attention to Response Task (SART; Smallwood et al., 2004), comparing mindfulness to distraction and no-instruction comparison groups. Two significant effects found that mindfulness significantly improved performance on the Stroop task when compared with a reappraisal-induction and-no instruction comparison groups (Keng et al., 2013). One study reported improved working memory performance following mindfulness when compared with a distraction induction (Weger et al., 2012), and the final study found that an attention exercise reduced interference on an emotional Stroop test more than a mindfulness induction, although this measure was taken at postinduction only (Watier & Dubois, 2016). Two studies lacked sufficient data to calculate effect sizes (McHugh, Procter, Herzog, Schock, & Reed, 2012; Bing-Canar, Pizzuto, & Compton, 2016). McHugh and colleagues (2012) reported significant positive effects of the mindfulness induction on measures of Set-Shifting, measured using a fixed-interval schedule, compared with mind wandering. Comparatively, Bing-Canar et al. (2016) reported

Table 3
*Effect Sizes and 95% Confidence Intervals for Mindfulness Induction Compared With Comparison Groups on Measures of Emotion-Regulation Strategies*

| Strategy | CT | First author | Measure | EXI induction | MF *n* | CT *n* | SMD | LCI | UCI |
|---|---|---|---|---|---|---|---|---|---|
| Experiential Avoidance | MW | Carlin | TP | Fear | 25 | 25 | .31 | −.24 | .87 |
| | MAL | Hooper | IRAP | Negativeaffect | 15 | 9 | .13 | −.70 | .96 |
| | | Hooper | AAQ | Negativeaffect | 15 | 9 | .28 | −.54 | 1.12 |
| Decentering | AAR | Feldman[1] | TMS | None | 68 | 63 | .33 | −.02 | .67 |
| | | Feldman[2] | TMS | None | 68 | 59 | **.40** | **.05** | **.75** |
| Rumination | AAR | Hilt[3] | VAS | Negativeaffect | 31 | 33 | −.37 | −.87 | .12 |
| | | Villa[1] | VAS | Negativeaffect | 38 | 37 | **−.48** | **−.94** | **−.02** |
| | DIS | Hilt | VAS | Negativeaffect | 31 | 32 | .09 | −.40 | .58 |
| | MW | Cooke-Long | ARS | Injustice | 27 | 25 | **−1.30** | **−1.89** | **−.70** |
| | NOIN | Villa | VAS | Negativeaffect | 38 | 36 | **−2.09** | **−2.65** | **−1.52** |
| Response Modulation | DIS | Yusainy | TCRT | None | 30 | 29 | −.01 | −.51 | .52 |

*Note.* CT = comparison group; MW = mind wandering; MAL = maladaptive alternative regulation; AAR = alternative adaptive regulation; DIS = distraction; NOIN = no instruction; *n* = number of participants in induction group; MF = mindfulness; SMD = standardized mean difference; LCI = lower confidence intervals; UCI = upper confidence intervals; TP = task persistence; IRAP = Implicit Relational Assessment Procedure; AAQ = Acceptance and Action Questionnaire; TMS = Toronto Mindfulness Scale; VAS = Visual Analogue Scale; ARS = Anger Rumination Scale; TCRT = Taylor competitive reaction time task; EXI = experimental induction. Significant effect sizes are in boldface.
[1] Muscle relaxation. [2] Loving-kindness meditation. [3] Problem solving.

Table 4
*Effect Sizes and 95% Confidence Intervals for Mindfulness Induction Compared With Comparison Groups on Measures of Executive Functions*

| EF component | CT | First author | Measure | MF *n* | CT *n* | ES | LCI | UCI |
|---|---|---|---|---|---|---|---|---|
| Inhibition | AAR | Keng (2013)[1*] | Stroop | 43 | 43 | **−.67** | **−1.10** | **−.23** |
| | | Keng (2017)[1*] | Stroop | 38 | 43 | .20 | −.24 | .64 |
| | DIS | Larson | Flanker Err | 28 | 27 | −.20 | −.73 | .33 |
| | | Larson | Flanker RT | 28 | 27 | −.03 | −.87 | .19 |
| | | Mrazek | SART Err | 19 | 20 | **−.77** | **−1.42** | **−.12** |
| | | Mrazek | SART RT CV[a] | 19 | 20 | **−.72** | **−1.37** | **−.08** |
| | | Watier[2] | Stroop Emo | 25 | 23 | **.79** | **.20** | **1.38** |
| | | Watier[3] | Stroop Emo | 25 | 24 | .50 | −.07 | 1.07 |
| | MAL | Keng (2017)[4*] | Stroop | 38 | 42 | .40 | −.04 | .85 |
| | | Mrazek | SART Err | 19 | 21 | **−.93** | **−1.59** | **−.27** |
| | | Mrazek | SART RT CV | 19 | 21 | **−.73** | **−1.38** | **−.09** |
| | NOIN | Keng (2013)[*] | Stroop | 43 | 43 | **−.55** | **−.98** | **−.12** |
| Shifting | AAR | Johnson[1] | TMA | 41 | 25[1] | −.30 | −.80 | .21 |
| | | Johnson | TMB | 41 | 25 | −.09 | −.59 | .41 |
| | DIS | Johnson | TMB | 41 | 26 | .28 | −.22 | .77 |
| | | Johnson | TMA | 41 | 26 | .32 | −.18 | .81 |
| Updating | AAR | Johnson[5] | DSB | 41 | 25 | −.15 | −.65 | .35 |
| | | Johnson | TB | 41 | 25 | −.12 | −.62 | .38 |
| | | Johnson | DSF | 41 | 25 | −.09 | −.59 | .41 |
| | | Johnson | SDMT | 41 | 25 | .07 | −.43 | .57 |
| | DIS | Weger[*] | Maths | 18 | 18 | **.94** | **.24** | **1.63** |
| | | Johnson | DSB | 41 | 26 | −.24 | −.73 | .26 |
| | | Johnson | DSF | 41 | 26 | −.23 | −.73 | .26 |
| | | Johnson | SDMT | 41 | 26 | −.19 | −.68 | .30 |
| | | Johnson | TB | 41 | 26 | .06 | −.43 | .56 |

*Note.* AAR = alternative adaptive regulation; DIS = distraction; MAL = maladaptive alternative regulation; NOIN = no instruction; *n* = number of participants in induction group; *S*MD = standardized mean difference, LCI = lower confidence intervals; UCI = upper confidence intervals; RT CV = reaction time coefficient of variability; TMA = Trail Making Test A; DSB = Digit Span Backward; TB = Two-Back task; DSF = Digit Span Forward; TMB = Trail Making Test B; SDMT = Symbol Digit Modalities test; SART = sustained-attention-to-response task; Err = error; RT = reaction time; Emo = emotional; Inc = incongruent, FIX = fixed interval schedule. Significant effect sizes are in boldface.
[1] Reappraisal. [2] Active attention. [3] Mathematics. [4] Thought suppression. [5] Sham meditation.
[a] RT CV or reaction time of coefficient variability calculated by the authors as standard deviation of reaction time divided by mean reaction time.
[*] Experimental design included an additional experimental induction (see table 1 for details).

no effect of mindfulness or distraction induction on errors or reaction time on the Stroop task. The remaining 68% of effect sizes were not significant and the overall interpretation of the evidence for an effect of a mindfulness induction on executive functions tended toward a nonsignificant or no effect, with some evidence supporting effects for Inhibition.

## Discussion

In this systematic review, we have presented a meta-analysis and synthesis of published papers reporting the effects of a laboratory-based mindfulness induction on measures of three aspects of self-regulation: the regulation of experimentally induced negative affect (meta-analysis), emotion-regulation strategies, and EFs (narrative synthesis). The results demonstrated that a mindfulness induction enhanced immediate emotion regulation beyond that of other activities (e.g., mind wandering), but equally to the effect of distraction. A mindfulness induction also significantly enhanced EFs, particularly inhibition, only in cases in which the study design included an affect induction, or in which sustained attention was the EF aspect measured; there was little other evidence for an effect on EFs. Similarly, there was mixed evidence for a significant effect of a mindfulness induction on emotion-regulation strategies; significant effects were limited to measures of rumination, such that a mindfulness induction reduced the use of this strategy.

The comparable results observed between mindfulness inductions and distraction can be understood in the context of theoretical models of emotion-regulation strategies. Distraction is an effective emotion-regulation strategy, as it acts to redirect attention (attention redeployment) away from the emotive stimuli (Gross & Thompson, 2007). The process model of emotion regulation has four stages that can be targeted for different emotion-regulation strategies: the emotive situation, attention deployment, cognitive appraisals, and emotion expression (Gross, 1998, 2001). Compared with distraction, mindfulness is proposed to act at a later stage of the process model (Gross, 1998) as a cognitive change process in which emotions or emotive stimuli are reappraised, specifically through fewer negative appraisals and increasing nonjudgment toward the experience (Webb et al., 2012). Many of the mindfulness inductions included instructions to be accepting or nonjudgmental toward experiences (which is consistent with the mindfulness axiom of attitude; Shapiro et al., 2006) and through which, may have targeted the regulation of emotions through an attitudinal change. However, more typically, the mindfulness-induction content focused on attention rather than acceptance, which could have supported the primary mechanism of the mind-

fulness induction as acting on attention deployment and, in turn, explain the present findings.

In support of this explanation, the equal effect of the mindfulness and distraction inductions suggests that both may have been acting on the attention axiom of mindfulness to redeploy attention away from the emotional experience without necessarily altering attitude. Even if the mindfulness inductions were acting only on the attention axiom, it would likely result in a degree of cognitive change, as it has been proposed that attention regulation can reduce or inhibit elaborative processing of emotive stimuli (Bishop et al., 2004). The notion that a mindfulness induction acted to alter attention but not attitude is supported by the inconclusive evidence in the present review that found that there was no effect of a mindfulness induction on decentering or reperceiving. Similarly, there was only tentative support for the effect of a mindfulness induction to reduce rumination. Rumination is an example of a maladaptive regulation strategy when applied to negative affect, as it often acts to intensify the emotional state (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008), which is contrary to the intended regulatory effect. In contrast, the present review reported that mindfulness significantly enhanced sustained attention, even when compared with distraction (Mrazek et al., 2012). This finding supports the notion that a mindfulness induction was acting to alter attention and suggests this mechanism may have extended beyond attention redeployment to support attention control (i.e., maintaining focused attention on a new stimulus). The cultivation of attention control is proposed as a core competency gained during early stages of meditation practice (Hölzel et al., 2011), and the present findings give tentative support to immediate gains on attention control following a single mindfulness induction.

Alternatively, these findings may be explained, in part, by the other comparison induction activities (i.e. mind wandering, maladaptive emotion-regulation strategies, no instructions) inflating the effect of mindfulness and distraction by negatively enhancing or maintaining the state of negative affect in the comparison groups. There is some evidence demonstrating that mind wandering can result in increased negative affect (Smallwood & Schooler, 2006), which may be because it lies on a continuum with perseverative cognitions, such as rumination and worry (Ottaviani, Shapiro, & Couyoumdjian, 2013).

The findings of the present review indicate that mindfulness induction significantly enhanced the inhibition and updating components of EFs only when additional experimental induction was included in the design (e.g., affect induction or stereotype threat). It has been proposed that all self-regulation failures are caused by impaired functioning of EFs (Hofmann et al., 2012). High levels of emotional arousal require bottom-up attention and emotion regulation to regain EF capacity (Blair & Ursache, 2011). The strength model of self-regulation (Baumeister & Heatherton, 1996) proposes that there is a shared cognitive resource with a limited capacity, which can be drained by demands placed on the self-regulatory system. Negative affect can drain self-control resources and consequently reduce the capacity to inhibit prepotent responses or sustain attention (see Wagner & Heatherton, 2014). Therefore, mindfulness induction may have enhanced EF indirectly by more effectively regulating emotion, thereby reducing cognitive load and increasing the resources available for subsequent demands on EF.

The findings of the review can be understood within existing frameworks that explain the association between mindfulness and self-regulation. In particular, Hölzel et al. (2011) and Tang et al. (2015) both proposed that attention control and emotion regulation are two of the mechanisms through which mindfulness exerts change on self-regulation. In particular, these models review neurocognitive evidence that, in novice meditators, greater attention control can be achieved through greater top-down control, as demonstrated by increased activity in prefrontal brain regions. Similarly, attention control is implicated as a means for emotion regulation for individuals selectively attending to nonemotive stimuli or by engaging in secondary tasks that are distracting (Hölzel et al., 2011). The findings from the current review, that mindfulness induction can regulate negative affect as effectively as activities designed to distract attention, and that mindfulness induction recovered EFs following an emotional induction, fit within these proposed models of the effects of mindfulness on self-regulation (Hölzel et al., 2011; Tang et al., 2015).

The present review provides some evidence for reduced rumination, but little or no support for changes to other emotion-regulation strategies, such as decentering, experiential avoidance, or response modulation. These findings are not explained by the proposed associations between mindfulness meditation and cognitive changes (including through either reappraisal or nonappraisal of experiences, or through greater experiential exposure) within existing models of mindfulness and self-regulation (Hölzel et al., 2011; Tang et al., 2015). However, the present findings may not be well-represented by existing models, as these models are based on findings from all forms of mindfulness research, including dispositional mindfulness with long-term meditators. Conversely, the present review includes reports only on the immediate effects of a one-time meditation practice. There is disparity between the existing models and the significant findings of the present review, in particular, that EFs were only enhanced under particular circumstances and decentering did not increase after mindfulness induction. Speculatively, this may be because cognitive change processes such as reappraisal or experiential exposure require greater duration and breadth of mindfulness training than is offered by a single mindfulness practice. However, even reviews of evidence from randomized controlled and quasi-experimental trials of MBIs have reported mixed effects on components of self-regulation, and these findings are equally unexplained by existing theoretical models (e.g., Chiesa et al., 2011; Lao et al., 2016). The interpretations of the present review are useful to provide greater understanding of the specific effects of a mindfulness induction in an experimental setting, and perhaps inform the differential effects reported across all forms of mindfulness research.

Foremost, the intention of the present review was to help determine whether mindfulness induction could elicit an immediate effect on self-regulation and to interpret these findings in accord with existing theoretical and empirical evidence. Moreover, the findings of the review and, in particular, the unique features of the mindfulness-induction design, may be extrapolated to evidence from other, more typical, investigations of extensive mindfulness training or dispositions. One way in which experimental mindfulness inductions are unique is that participants have the intention to engage in a research experiment rather than engage specifically with mindfulness practice. Shapiro et al. (2006) promoted the importance of intention along with attitude and attention in their

intention, attention, and attitude (IAA) model of mindfulness as mechanisms that facilitate change following mindfulness training. The way in which the intention component of mindfulness may impact a mindfulness induction effecting change on self-regulation is unclear, but it could be hypothesized that it partly explains why existing models of mindfulness and self-regulation extend beyond the findings of the present review. Tang et al. (2015) highlighted that, for novice meditators, there is relatively greater mental effort required to achieve a meditative state than for more experienced meditators which may, in turn, support the notion that intention and motivation are most important for those new to meditation.

Existing evidence demonstrates the importance of study methodology in determining the strength and significance of detected effects in experimental, cross-sectional emotion-regulation research (for review see Webb et al., 2012). Similarly, an effect of study methodology was found on effect sizes for a number of variables in the present review, for example, between pre–posttest and posttest designs, or in cases in which different outcome measures were used. The influence of methodological design may extend beyond the meta-analysis to the other outcomes of this review. Methodological differences other than those already mentioned (e.g., nature of comparison induction, inclusion of an emotion induction) could therefore account for the differential findings for EFs and emotion-regulation strategies. The methodological heterogeneity of the two outcomes (emotion-regulation strategies and EFs) was deemed to be too great for statistical synthesis in a meta-analysis. Although emotion-regulation strategies and EFs can be understood within a unitary construct (Miyake et al., 2000; Gross, 1998), they are assessed using numerous and varied outcome measures. Therefore, it is difficult to determine the role of possible methodological mediators on the presence or absence of significant effects for these outcomes.

## Future Directions and Limitations of Included Evidence

The present research findings offer direction for further empirical exploration. Some of the conclusions of the review, in particular, evidence for the effects of a mindfulness induction on rumination and sustained attention, and absence of an effect on decentering, are derived from the limited number of included studies. In addition, many of the included studies were rated as weak in quality. Therefore, further testing of these tentative findings applying and reporting more rigorous methodological standards would be beneficial, particularly to address the generalizability of the participant samples, validity of outcome measures, and double-blind procedures.

The present review employed broad inclusion criteria for the mindfulness inductions, as no established classification system has been proposed, unlike for MBI (Crane et al., 2017). The evidence base would benefit from more stringent criteria for what does and does not classify as a mindfulness induction, and specifically, from authors providing access to full scripts of the mindfulness induction used. Particularly, this would allow reviewers in the future to further explore the impact of the content of practices on outcomes, specifically the inclusion and emphasis of instructions pertaining to attitude and attention components of mindfulness. In addition, further research would benefit from information from existing evidence (such as Webb et al., 2012), as well as the evidence from the present review, that highlights the significance of selected methodologies in determining the strength and detection of effects. Specifically, this includes the choice of comparison induction and, when included, the personal relevance and specificity of the emotion induction.

## Limitations of the Present Study

This review provides evidence for the immediate effects of a mindfulness induction on self-regulation, in particular through the regulation of negative affect and subsequent gains in EFs, and through gains in sustained attention. The review is limited in the extent to which it can expand our understanding of the temporality of effects of a mindfulness induction, as all included data were for measures of immediate effects. As an initial step in reviewing the evidence using mindfulness inductions experimentally, the scope of the review was focused to include only nonclinical participants and the affective and cognitive aspects of self-regulation. The present findings may give impetus for additional reviews to further explore this method as applied in clinical samples and also self-regulation measured through physiological and neurological outcomes. In addition, as with all review processes the present research may have been influenced by biases (e.g., study selection); however, attempts were made to mitigate against such biases whenever possible, for example, two researchers coded the comparison-group categories and appraised the quality of the included studies. A further inclusion criterion was that all included papers were peer-reviewed, although the estimation of publication bias and the fail-safe *N* (Rosenthal, 1979) mitigated against this potential limitation, which demonstrated that although some nonsignificant findings may not have been published, the effect size of the meta-analysis was robust and representative of the overall findings.

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