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Experimental effects of mindfulness inductions on self-regulation: systematic review and meta-analysis

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Running head: mindfulness induction on self-regulation

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Self-regulation is the control of aspects of the self to allow the pursuit of long-term goals, and it is proposed as a central pathway through which mindfulness may exert benefits on wellbeing. However, the effects of a single mindfulness induction on self-regulation are not clear as there is no comprehensive review of this evidence. The current review synthesised 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 three 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 functions performance was enhanced only where the experimental design included an affect induction or 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 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 behaviors 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 non-clinical populations and are negatively associated with physical health, management of personal finances and criminal offending (Moffitt et al., 2011). Self-regulation is a complex function relying on multiple cognitive and affective systems, and effective symbiosis between these systems. The most pertinent systems are executive functions (EFs) and emotion regulation. The discussion of self-regulation will therefore be presented here with consideration of self-regulation via 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 bi-directional model of EFs and self-regulation has been proposed that presents the constructs as operating in an interactive feedback loop (Blair & Urasche, 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 & Urasche, 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 exemplar, 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, where behaviours are enacted that are not in line with long term goals and a state of negative affect persists.

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 (Larazus, 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 stages are the emotive situation, the deployment of attention, cognitive appraisals and emotion expression. Each stage has 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 is proposed that engaging in emotion regulation strategies at an earlier stage of the process is more cognitively efficient and effective (Gross, 2001). For example, exiting the emotive situation (situation selection) uses less 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 behaviour denotes that the primary mechanism of most emotions is to inform cognition, which can in turn elicit behaviours or behaviour changes (Baumeister, Vohs, DeWall, & Zhang, 2008). In some cases behaviour may be directly guided by reflexes (e.g. flight or fight) or highly charged emotions. These reflexes, such as as an urge to flee a situation, can impair EFs and result in impulsive behaviours. These impulsive

actions may not be in line with long-term goals. Emotions are considered far more challenging to regulate than cognitions or behaviours and often they require the most complex interventions and strategies to elicit change (Baumeister, Vohs, DeWall, & Zhang, 2007; Baumeister, Heatherton, & Tice, 1994).

1.1 Mindfulness and self-regulation: theoretical models

Mindfulness meditation is often described as non-judgemental attention and acceptance of present moment experience (Brown & Ryan, 2004). Several theoretical models include self-regulation as a proposed mechanism of change of 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 meta-cognitive function, reperceiving requires a process of stepping back from an experience in order 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 manner 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, e.g. towards 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 behavioural 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 framework 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 behavioural 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 non-attachment or decentering.

An alternative model proposes three axioms of mindfulness: intention (reason underpinning choice to practice mindfulness), attention (observation of moment-to-moment experience) and attitude (of acceptance, kindness and openness). These three axioms underpin a meta-mechanism of ‘reperceiving’, which then gives rise to several mechanisms of change, including self-regulation (Shapiro et al., 2006). In a similar manner 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 the mindfulness practice by the individual. It is

these axioms that determine the spirit with which one is paying attention and motivates one to practice mindfulness (Shapiro et al., 2006).

1.2 Mindfulness interventions and inductions

Mindfulness-based interventions (MBIs) are typically formed of eight weeks of mindfulness training that encompasses experiential exercises (e.g. mindfulness of breathing, body scan), group discussions, home practices and psycho-education 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 (Eberth & Sedlmeier, 2012; Gu, Strauss, Bond, & Cavanagh, 2015) and mixed evidence for significant positive effects on EFs (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 interventions, they found no randomised 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-off novel practice, referred to here as a mindfulness induction. A mindfulness induction is an experiential mindfulness practice that may form part of an MBI programme, for example mindfulness of breathing, loving kindness and acceptance practices. As an exemplar of a mindfulness induction, Arch and Craske (2006) utilised a 15-minute guided practice focussing attention on present moment sensations, including the breath, before assessing emotion regulation. A mindfulness induction utilised 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, Hölzel, & Posner, 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 home work practices. Additionally, 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 improved executive attention (Kuo & Yeh, 2015; Gorman & Green, 2016). In a review of neurobiological evidence, three mindfulness induction studies (comparing to no-control, cognitive reappraisal and no instruction) measuring functional magnetic resonance imagery provide 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 pre-existing 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 non-clinical population, self-regulation can be more precisely considered. One reason for this is because the presentation of self-regulation difficulties in non-clinical populations is more homogenous and is not interacting with other aspects of a complex clinical

presentation. Therefore, as the initial attempt to consolidate evidence in this field, this review is focussed on self-regulation in a non-clinical population. This focus can broaden our understanding of the theories and mechanisms of mindfulness, which can 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, behavioural, physiological and neurological areas of functioning. This 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 measured using behavioural and self-report means. This spotlight on the evidence corresponds 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. Additionally, there is empirical support for the affective and cognitive aspects of self-regulation as a target for mindfulness training and theoretical evidence of self-regulation as a possible mechanism of mindfulness.

Specifically, the review reports on outcomes for emotion regulation and EFs, as these emerged as appropriate subgroups for the outcomes of the articles that met the inclusion criteria. Emotion regulation is measured in two ways, the regulation of experimentally induced negative affect and 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 aim to explore whether a mindfulness induction can enhance self-regulation compared to alternative inductions.

2. Method

2.1 Search strategy

Major psychological and related databases (PsycINFO; PsychARTICLES; MEDLINE, Web of Science and ProQuest Dissertation & Theses) were searched using descriptors for the three key search areas: mindfulness meditation ("mindfulness*"; "loving kindness"; "mindful"; "body scan"; or "focussed attention"); experimental laboratory design ("experimental" or "laboratory") and brief mindfulness induction ("brief"; "induction"; "instruction"; "short"; "single"; or "one"). Database tools were utilised 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 in May 2017.

2.2 Selection Criteria

A flowchart of the study selection process is shown in Figure 1. Qualifying studies fulfilled five selection criteria: (1) experimental design where participants were allocated to a mindfulness induction or comparison group and all data was 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; (2) A 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. (3) Participants were drawn from a general non-clinical population, extending exclusions to those who selected a subsection of non-clinical participants e.g. heavy drinkers, elevated depression. Data collection occurred independently (e.g. not through group interactions) and the majority of the participant sample had no previous meditation experience; (4) 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; (5) Status of publication included peer reviewed publications written in English.

The papers included in the three outcome groups: regulation of negative affect, emotion regulation strategies and EFs, were considered with regards to their methodological similarity, for example the outcome measures, order of induction, 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 (6) randomisation to experimental group, (7) induction of negative affect (e.g. sadness, anger) and (8) 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 analysed 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.

[Figure 1]

2.3 Quality appraisal

The quality of included papers was assessed using the Effective Public Health Practice Project 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 is made according to the following: strong (overall no weak components), moderate (overall 1 weak component) or weak (overall 2 or more weak components). The withdrawals and drop-outs item of the EPHPP was adapted to include participant data that was excluded for any reason (e.g. technical error), in order to accurately capture the number of participants whose data was collected in part or in full but subsequently not analysed. 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.

2.4 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 post-graduate 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). Where 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 (emotion regulation strategies, 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.

2.5 Calculation of effect sizes

Standardised mean differences 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 pre-test standard deviation was utilised, as it is a more consistent estimate of variance between groups

because there is no effect of the experimental manipulation (Becker, 1988). Where insufficient data was reported (k = 10), corresponding authors were contacted to obtain access to data; where this was not provided (k = 3), test statistics were used to calculate effect sizes (k = 1) or the findings were presented as a narrative summary only (k = 2). Standardised mean differences 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 each effect size distribution interacts with the between study variance component (τ^2, Hedges & Vevea, 1998). This approach allows for broader generalisation 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).

2.6 Heterogeneity and publication bias

For meta-analytic data, heterogeneity of effect sizes was determined using the Q-statistic and I^2 values. The Q-statistic 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 that is 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 et al, 2005) and for this review the effect of publication bias was assessed visually on a funnel plot (Egger, Smith, Schneider, & Minder, 1997) and through calculation of the Fail Safe N (Rosenthal, 1979). The funnel plot represents the distribution of study effect sizes against the standard error of effects. In the current sample a bias would be identifiable 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 number of studies that favour the comparison induction that would need to be published in order to eliminate the effect of publication bias on the meta-analysis outcome

(Duval & Tweedie, 2000). The fail safe N indicates the number of missing studies that have a mean effect of zero that would need to be added to the existing studies before the combined effect is no longer statistically significant.

3. Results

Twenty-seven studies met inclusion criteria (Figure 1) but only a subset of included articles was deemed suitably methodologically homogenous to be entered in to 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 synthesised narratively for outcomes pertaining to emotion regulation strategies (k = 7) and EFs (k = 9; Figure 1). These papers were methodologically heterogeneous with regards to 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). Additionally, a subset of these papers included other experimental manipulations (e.g. affect induction; k = 19; Table 1).

3.1 Quality

Overall the quality of the included papers was rated as weak in both the meta-analysis (k = 11) and narrative synthesis (k = 14; Table 1) based on the criteria of the EPHPP appraisal tool. The areas of weakness particularly related to the generalisability of the samples as most were from undergraduate populations (k = 26), failure to report on or use valid and reliable outcome measures (k = 20) and non-reporting or unclear reporting of 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.

3.2 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 gave instructions to: aware of the breath or body (k = 24), focus attention (k = 14) and acceptance of 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-minutes (SD = 3 minutes; range = 5-25 minutes). 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).

[Table 1 approx. here]

3.3 Mindfulness induction and the regulation of negative affect

The meta-analysis included data from 15 peer-reviewed studies (Table 1) generating 15 effect sizes between d = -0.80 and 0.46 (Figure 2). Twelve effect sizes were not significant with the remaining three favouring a mindfulness induction (Cooke-Long & Christian, 2015; Kiken & Shook, 2014; Villa & Hilt, 2014). The weighted mean effect of a mindfulness induction on regulation of negative affect was $SMD_{weighted}$ = -0.28, 95% CI = [-0.44, -0.11], Z = 3.24, p = .001 confirming that a mindfulness induction regulated 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) and a non-significant Q statistic indicating low statistical differences between included studies. The funnel plot tails appeared balanced and the fail safe N (number of unpublished papers required to change the Z value to non-significant) was k = 879, which was greater than the estimated 85 unpublished studies.

[Figure 2 approx. here]

Seven subgroup analyses were conducted to assess the effect of methodological differences between study designs on the pooled estimates of effect (Table 2). There was no significant difference between mindfulness and distraction on the regulation of negative affect, whereas mindfulness was superior to all other comparison inductions in reducing negative affect. There was only a significant effect of mindfulness on negative affect where the emotion induction targeted a specific emotion (e.g. sadness) rather than general negative affect, where the mindfulness induction preceded the emotion induction and where the method of emotion induction was more personally relevant (e.g. recall of personal event). Effect sizes were only significant where pre-post-test designs were used and where affect was measured using means other than the PANAS (e.g. visual analogue scales of state affect). The effect of order of delivery of the mindfulness and emotion induction may mean that the mindfulness induction acted to prime participants to process the emotion induction differently to those who practiced mindfulness after the emotion induction. A meta-regression of duration of mindfulness induction (range = 5-15 minutes) did not reveal any effect of induction length and there was no association between duration of mindfulness induction and effect size strength $r = .03$, $p = .919$.

[Table 2 approx. here]

3.4 Mindfulness induction and emotion regulation strategies

Seven articles reported the effect of a mindfulness induction on emotion regulation strategies generating 11 effect sizes (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%) from three studies (Cooke-Long & Christian, 2015; Feldman et al., 2010; Villa & Hilt, 2014) were significant and a mindfulness induction with effect sizes ranging from .40 to -2.09. Three of the significant effects were for measures of rumination (of $k = 5$ measuring rumination) demonstrating a significant effect of a mindfulness induction to reduce rumination when compared to mind wandering and no instruction comparison groups.

Contrastingly, the effect was not conclusive when compared to other adaptive regulation instructions (e.g. problem solving) and was equal to the effects of distraction.

[Table 3 approx. here]

3.5 Mindfulness induction and EFs

Nine studies reported the effect of a mindfulness induction on EFs (Table 4), with seven studies having sufficient detail to generate 25 effect sizes. Outcome measures reflected Miyake's classification of EFs (2000): updating (including working memory), set-shifting and inhibitory control. Three studies utilised an additional experimental induction of sadness (Keng et al., 2013; Keng et al., 2017) or stereotype threat (Weger et al., 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 and colleagues (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 mindfulness significantly improved performance on the Stroop task when compared to a reappraisal induction and no instruction comparison group (Keng et al., 2013). One study reported improved working memory performance following mindfulness when compared to a distraction induction (Weger et al., 2012) and the final study found that an attention exercise reduced interference on an emotional Stroop more than a mindfulness induction, although this measure was taken at post-induction only (Watier & Dubois, 2016). Two studies lacked sufficient data to calculate effect sizes (McHugh et al., 2012; Bing-Canar et al., 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 to mind wandering. Comparatively, Bing-Canar and colleagues (2016) reported 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 tends towards a non-significant or no effect, with some evidence supporting effects for inhibition.

[Table 4 approx here]

4. Discussion

This systematic review presents 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 equal to the effect of distraction. A mindfulness induction also significantly enhanced EFs, particularly inhibition, only where the study design included an affect induction or where the aspect of executive function measured was sustained attention; 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 to distraction, mindfulness is proposed to act at a later stage of the process model of emotion regulation (Gross, 1998) as a cognitive change process where emotions or emotive stimuli are reappraised, specifically through fewer negative appraisals and increasing non-judgement towards experience (Webb et al., 2012). Many of the mindfulness inductions included instructions to be

accepting or non-judgemental toward experiences, in line with the mindfulness axiom of attitude (Shapiro et al., 2006) and through this may have targeted the regulation of emotions through an attitudinal change. However, more typically the mindfulness induction content focussed on attention rather than acceptance and so this could have supported the primary mechanism of the mindfulness 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, this 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 was acting 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 et al., 2008), which is contrary to the intended regulatory effect. Contrastingly, the present review reported that mindfulness significantly enhanced sustained attention even when compared to 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 (maintaining focussed 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 (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) and this may be because it lies on a continuum with perseverative cognitions, such as rumination and worry (Ottaviani, Shapiro, & Couyoumdijian, 2013).

The present review reports that a mindfulness induction significantly enhanced the inhibition and updating components of EFs only where an additional experimental induction was included in the design (affect induction or stereotype threat). It has been proposed that all self-regulation failures are due to impaired functioning of the EFs (Hofmann et al., 2012). High levels of emotional arousal require bottom up attention and emotion regulation to regain EFs capacity (Blair & Urasche, 2011). The strength model of self-regulation (Baumeister & Heatherton, 1996) proposes that there is a shared cognitive resource that has 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, a mindfulness induction may have enhanced the EFs indirectly by more effectively regulating emotions, thereby reducing cognitive load and increasing the resources available for subsequent demands on the EFs.

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 propose 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 that sees increased activity in prefrontal brain regions. Similarly, attention control is implicated as a means for emotion regulation by individuals selectively attending to non-emotive stimuli or by engaging in secondary tasks that are distracting (Hölzel et al, 2011). The findings from the current review, that a mindfulness induction can regulate negative affect as

effectively as activities designed to distract attention and that a mindfulness induction recovered EFs following an emotional induction, fit within these proposed models of 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 were based on findings from all forms of mindfulness research including dispositional mindfulness and with long-term meditators. Conversely, the present review reports on only the immediate effects of a one-off 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 following a 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 randomised controlled and quasi-experimental trials of MBIs report mixed effects on components of self-regulation and these findings are equally not explained by existing theoretical models (e.g. Chiesa, Calati, & Serretti, 2010; Lao, Kissane, & Meadows, 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.

Foremostly, the intention of the present review was to help determine whether a 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 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) promote the importance of intention alongside attitude and attention in their IAA model of mindfulness, as mechanisms that facilitate change following mindfulness training. The way in which the intention component of mindfulness may impact on a mindfulness induction effecting change on self-regulation is unclear but it could be hypothesised that this may in part explain why existing models of mindfulness and self-regulation extend beyond the findings of the present review. Tang et al. (2015) highlight that for novice meditators there is relative greater mental effort required to achieve a meditative state than for more experienced meditators and this in turn may 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). The present review similarly found an effect of study methodology on effect sizes for a number of variables, for example between pre-post-test or post-test designs, or where 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 (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 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.

4.1 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 only limited numbers of included studies. Additionally, many of the included studies were rated as being of weak quality. Therefore, further testing of these tentative findings utilising and reporting more rigorous methodological standards would be beneficial, particularly to address the generalisability 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 future reviews 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. Additionally, further research would benefit from being informed by existing evidence (such as Webb et al., 2012) and 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.

4.2 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 non-clinical 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. Additionally, 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 these wherever possible, for example two researchers coded the comparison group categories and quality appraised the included papers. A further inclusion criteria was that all included papers were peer-reviewed, although this potential; limitation was mitigated against by the estimation of publication bias and the Fail-Safe N (Rosenthal, 1979), which demonstrated that, although some non-significant 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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*indicates articles included in the systematic review

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