Exploring Emotional Memory as a Potential Mechanism Explaining the Effectiveness of Mindfulness

Master’s Thesis

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The Faculty of the Graduate School of Arts and Sciences
Brandeis University
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Ellen J Wright, Advisor

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Master of Arts
in
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by
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ABSTRACT
Exploring Emotional Memory as a Potential Mechanism Explaining the Effectiveness of Mindfulness
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Waltham, Massachusetts
By Bo Dong
Mindfulness has been found to improve psychological well-being. It has also been incorporated in many clinical interventions as an effective strategy against various psychological disorders. However, how mindfulness works is still unclear. Mindfulness emphasizes observing the present moments with fully awareness and non-reactivity, so it may change the way people remember things, especially for events containing strong emotional stimuli. It is possible that mindfulness reduces the bias towards negative memories, which is typically shown in depressed people. The current study investigated emotional memory as a potential pathway through which mindfulness training leads to improvement in psychological well-being as well as a decrease in psychological symptoms. Fifty-nine undergraduates were recruited for the study (69.5% female). Half of them were randomly selected to receive brief mindfulness training by listening to an audio guided mindfulness meditation tape, and the other half received music relaxation treatment. All of the participants viewed a set of pictures with positive, negative and neutral valences, and were given a recognition task. Participants who received mindfulness training had higher false alarm rates for positively valenced images, and higher false alarms for positive images were related to greater psychological well-being. The current study provided evidence that the effectiveness of mindfulness training could be explained by changes in emotional memory.
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Note: No difference was found between mindfulness and control group for each of the measures
Table 2. Correlations among the questionnaire measures

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<td>-.72**</td>
<td>.94**</td>
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Note: *p<.05, **p<.01, ***p<.001
Table 3. Hits, false alarms, corrected recognition and sensitivity in each condition

<table>
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<tr>
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<td>Negative</td>
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<td>Negative</td>
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<td>.84 (.16)</td>
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<td>Negative</td>
<td>.82 (.13)</td>
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<td><strong>Sensitivity</strong></td>
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<tr>
<td>Positive</td>
<td>.96 (.05)</td>
<td>.95 (.04)</td>
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<tr>
<td>Negative</td>
<td>.95 (.04)</td>
<td>.93 (.10)</td>
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</table>

*Note: The table showed each of the memory test scores for each group and image type.*
Figure 1. Time 1 and time 2 psychological well-being between the two conditions

Figure Caption: the graph illustrated the mean psychological well-being score at time 1 and time 2 separately for control group and mindfulness group. Time 2 well-being was significantly increased only in mindfulness group.
Figure 2. Time 1 and time 2 psychological distress between the two conditions

Figure Caption: the graph illustrated the mean psychological distress score at time 1 and time 2 separately for control group and mindfulness group. Time 2 distress was significantly decreased only in mindfulness group.
Introduction

Mindfulness, which originated in eastern Buddhism, is defined as a process of bringing one’s attention and awareness to the present moment in a nonjudgmental and accepting way (Brown & Ryan, 2003; Kabat-Zinn, 1990). A higher state of mindfulness is associated with a variety of well-being indicators, such as reduction in mood disturbance and stress, increase in psychological well-being, and improvements in many psychological problems such as depression, anxiety, eating disorders and personality disorders (Bach & Hayes 2002; Brown & Ryan, 2003; Nyklíček & Kuijpers, 2008). Moreover, the benefits of being mindful have been seen across different populations (e.g., patients with cancer). Jon Kabat-Zin first introduced the concept of mindfulness in the US and incorporated it into clinical practices. Jon Kabat-Zin designed the Mindfulness-Based Stress Reduction (MBSR); it has emerged as a new way to treat a variety of psychological disorders, eating disorders and anxiety disorders (Kabat-Zinn, 1990; Marchand, 2012). According to a meta-analytical study by Grossman, Niemann, Schmidt and Walach (2004), MBSR improved clinical and non-clinical problems with an average effect size of 0.5. Following MBSR, other mindfulness-based interventions such as Mindfulness Based Cognitive Therapy and Mindfulness Based Relationship Enhancement have also become popular (JW. Carson, KM. Carson, Gil, & Baucom, 2004; Segal, Williams, & Teasdale, 2002).

While many researchers are trying to demonstrate more benefits related with mindfulness, it is equally important to understand what makes mindfulness practice effective (Shapiro, Carlson, Astin & Freedman, 2006). However, only recently the question as to how or why
Mindfulness works has aroused researchers’ attention (e.g., Roberts-Wolfe, Sacchet, Hastings, Roth, & Britton, 2012; Taylor et al., 2011). Better understanding of the mindfulness mechanisms could provide an empirical rationale for using mindfulness practice to promote psychological health and alleviate psychological symptoms.

Several studies have examined emotion regulation as a mechanism through which mindfulness is associated with depressive and anxiety symptoms (e.g., Desrosiers, Vine, Curtiss, & Klemanski, 2014). Desrosiers, Vine, Klemanski and Nolen-Hoeksema (2013) found that rumination mediated the relationship between mindfulness and both anxiety symptoms and depressive symptoms. This supported transdiagnostic models of psychopathology, which categorizes disorders based on underlying mechanisms or core disturbances (Kring & Sloan, 2009). In addition, they also found that reappraisal mediated the association between mindfulness and depressive symptoms, as well as worry mediated the association between mindfulness and anxiety symptoms. Both rumination and worry involves maladaptive repetitive thoughts, with rumination focusing on previous negative events (Lyubomirsky, Caldwell, & Nolen-Hoeksema, 1998) and worry focusing on future threats (Watkins, 2008). The present-focused element of mindfulness is antithetical to the emphasis in either rumination or worry; thus, mindfulness may buffer the negative effects of rumination and worry (Desrosiers et al., 2013).

Although the study suggested that mindfulness was associated with better psychological outcome through an increase in adaptive emotion regulation strategy (i.e., reappraisal) and a decrease in maladaptive emotion regulation strategies (i.e., rumination and worry), the direction of these effects are unknown. Moreover, the mediation effects of emotion regulation, however significant, were not large.
Counterintuitively, some studies found that mindfulness was positively related to psychopathologies. The observing element in mindfulness was particularly associated with higher level of distress and anxiety symptoms (Baer, Smith, Hopkins, Krietemeyer, & Toney, 2006). Deroisers et al (2014) also demonstrated that observing was associated with depressive symptoms through rumination, and was associated with anxiety symptoms through worry. However, non-reactivity moderated the pathway to depressive symptoms, but not anxiety symptoms. Observing non-reactively might prevent individuals from automatically engaging in a maladaptive style of cognitive processing (i.e., rumination), and not being stuck in internal feelings or external experience (Desrosiers et al., 2014). However, the positive association between anxiety and observing remained significant even when combined with non-reactivity. Thus, the unique connection between observing and anxiety symptoms needs to be further explored.

Another set of studies examined emotional intelligence as a mediator between mindfulness and psychological well-being. Emotional intelligence refers to skills in four areas: accuracy in perceiving emotions, using emotions to facilitate thoughts, understanding emotions and managing emotions to improve personal and social functioning (Mayer, Salovey, & Caruso, 2008). Schutte and Malouff (2011) argued that the non-judgmental, self-regulating and being present nature of mindfulness might enhance emotional abilities and competencies, hence promoting greater emotional intelligence. Higher levels of trait emotional intelligence have been associated with positive affect, life satisfaction, social competence and many other aspects of psychological well-being that are common in people with high trait mindfulness (e.g., Austin, Saklofske, & Egan, 2005; Mavroveli, Petrides, Rieffe & Bakker, 2007). Indeed, emotional intelligence significantly mediated the positive association between mindfulness and the three
indicators of subjective well-being: higher positive affect, lower negative affect and higher life satisfaction (Schutte & Malouff, 2011). Consistent with that finding, Wang and Kong (2014) found that emotional intelligence partially mediated both the association between mindfulness and life satisfaction and the association between mindfulness and mental distress. The partial mediation effects suggested that emotional intelligence itself would not sufficiently explain the mechanism linking mindfulness and positive psychological outcomes.

Studies of emotion regulation and emotional intelligence have both provided a better understanding of why mindfulness practice works, yet their uniform reliance on cross-sectional design did not elucidate the direction of effects. Thus, more research needs to be done in order to comprehend the pathway through mindfulness to psychological well-being or psychopathologies.

Roberts-Wolfe et al. (2012) have suggested that mindfulness might affect how emotional information is processed. They referred to the cognitive model of depression (Beck, 1987), which stated that depressive people have biased attention and memory toward negative stimuli and away from positive stimuli (e.g., Burt et al., 1995). Mindfulness practice can be seen as a method to shift distressed individual’s attention and memory toward positive stimuli, which has been related to well-being (Fredrickson & Joiner, 2002; Taylor & Brown, 1994). Specifically, the current research is interested in whether mindfulness influences memory for positive relative to negative events differently.

To study how mindfulness may influence people’s emotional memory, first we need to investigate how mindfulness practice alters responses to emotional stimuli. Mindfulness helps individuals to develop the ability to insist on neither pursuing pleasant experiences nor intentionally forcing aversive experiences away (Shapiro, Carlson, Astin & Freedman, 2006). It
is likely that individuals high in mindfulness might be prone to remain detached or less engaged in emotional experiences, so that they encounter less distress.

Alternatively, mindfulness may allow individuals to be better able to fully engage in emotional experiences, but the non-reactivity and non-judgmental aspects might mitigate the effects brought by negative experiences. Greenberg and Meiran (2013) tested whether mindfulness was leading to “emotional blunting” or emotional engagement. It turned out that after receiving mindfulness meditation, participants took twice as longer time to recall a mood incongruent memory (e.g., after watching a sad movie, they took longer to recall the first happy memory). This result supported the emotional engagement hypothesis. They also suggested that mindfulness was associated with rapid recovery from emotion, since mindfulness meditators recalled as many mood incongruent memories as controls.

If mindfulness leads to engagement in both positive and negative emotional stimuli, but does not display the negative effects generated by negative stimuli; this finding should be further explained. Using brain neuroimaging, Taylor et al. (2011) discovered a consistent result of the processing of emotional stimuli in mindfulness meditators; mindfulness practice attenuated the intensity of perception from emotional stimuli. However, this attenuation was achieved through different mechanisms. For experienced meditators, mindfulness induced deactivations of regions related to the default mode network but did not influence brain activity in emotional reactivity brain areas. In contrast, for beginner meditators, mindfulness resulted in a down-regulation of the left amygdala during emotional processing. Either way, the study suggested that mindfulness encouraged a more relaxed, adaptive and objective response to all valences of emotional stimuli, and that mindfulness fostered emotional stability. Although this study compared beginner mindfulness meditators and experienced mindfulness meditators to address the effectiveness of
mindfulness training, a control group is needed to illustrate how mindfulness practice changes the processing of emotional stimuli.

Evans and Segerstrom (2011) evaluated the association between mindfulness and a variety of repetitive thoughts, in terms of valence, purpose and total amount of propensity to engage in repetitive thoughts (Segerstrom et al., 2003). Results indicated that mindfulness was associated with less total repetitive thoughts but more positive repetitive thoughts. It implied that practicing mindfulness is related with thinking positively.

To our knowledge, only two studies tentatively explored the relationships among mindfulness practice, emotional memory and psychological well-being/distress. Roberts-Wolfe (2012) studied emotional memory using a free word recall test, and found that mindfulness meditators recalled more positive words compared with participants who received music training; however, no significant difference was found for recall of negative words. In addition, mindfulness meditation training improved psychological well-being. The longitudinal design of the study enabled the temporal relationship between mindfulness, emotional memory and psychological well-being to be established. Nevertheless, one critical deficit in the design of the study was concerning. Instead of using true random design, participants in this study were asked to choose which training group they wanted to join. The consequence could be that currently distressed individuals were more likely to choose mindfulness group since they were seeking help, so the increase in positive word recall might be due to a regression to the mean.

Another study used a brief audiotaped mindfulness training to study its effects on a verbal word recall test (Alberts & Thewissen, 2011). An opposite pattern of results was yielded compared with the former study: participants that received mindfulness training recalled less negative words as opposed to more positive words. Neither of these two studies tested the
mediation role of emotional memory between mindfulness and psychological well-being, although psychological well-being was accompanied by either an increase in positive word recall or a decrease in negative word recall.

The current research examined the influence of a mindfulness meditation on emotional memory, the influence of emotional memory on psychological well-being/distress, and the connections with mindfulness. We gave participants a short mindfulness meditation practice which lasted 10 minutes and then tested their memory for pictures that contained emotional stimuli (positive vs. negative). We hypothesized that first, mindfulness meditation would increase psychological well-being and decrease psychological distress; second, those who received mindfulness meditation would have better memory for positive images and worse memory for negative images; third, more positive emotional memory and less negative emotional memory would each be associated with increase in psychological well-being and decreases in psychological distress; lastly, changes in emotional memory would mediate the relationship between mindfulness training and psychological well-being/distress.

In addition, the current study examined the potential involvement of emotion regulation. Emotion regulation includes a broad range of strategies we use to manipulate emotional responses (Gross, 1999a). People differ in their use of emotion regulation strategies. The current study analyzed whether emotion regulation moderated the association between mindfulness and psychological outcomes. Specifically, we hypothesized that people who use more adaptive emotion regulation strategies (i.e., cognitive reappraisal) would demonstrate higher level of psychological well-being and lower level of psychological distress; people who use more maladaptive emotion regulation strategies (i.e., expressive suppression and rumination) would demonstrate lower level of psychological well-being and higher level of psychological distress.
The findings would provide insight about under what conditions mindfulness appears to be more effective.
Methods

Participants

Participants were 59 undergraduate students (30.5% male, 69.5% female) of Brandeis University. Students received research credit or extra credit for participating in this study. Of the 59 participants, 1.8% identified as African American, 27.3% as Asian, 63.7% as Caucasian, 5.5% as Hispanic, and 1.8% as others. The participants ranged in age from 17 to 22 years (M=19.54, SD=.94).

Design

Participants first completed a packet of self-report questionnaires that measure cognitive reappraisal, expressive suppression, rumination, trait mindfulness, and demographic information. Then participants were randomly assigned into two groups: one received mindfulness training and the other received music relaxation break as control. Both groups were be asked to view a slide show of emotional images and do a memory test following that.

Measures

Emotion Regulation. Emotion Regulation Questionnaire (ERQ; Gross and John, 2003) measures individual differences in the habitual use of two emotion regulation strategies: expressive suppression and cognitive reappraisal. Expressive suppression, as opposed to cognitive reappraisal, is considered as a maladaptive strategies that has been associated with stress-related symptoms (Moore, Zoellner & Mollenholt, 2008). The tendency to use effective/adaptive emotion regulation strategy or ineffective/maladaptive strategies may tease apart the effect as to under which conditions mindfulness practice works better. Participants were
asked to answer each item on a 7-point Likert-type scale ranging from 1 (strongly disagree) to 7 (strongly agree), with sample item as “I keep my emotions to myself”. Internal consistency (α = .73 for cognitive reappraisal, and α = .78 for expressive suppression) was comparable to what has been found in previous studies using the ERQ (Stephen, Steven, Andrew, & Benjamin, 2011; Gross & John, 2003).

**Brooding.** The Brooding subscale of Ruminative Response Scale (RRS-B; Treynor, Gonzalez, & Nolen-Hoeksema, 2003) measures an individual’s dispositional tendency to ruminate. The brooding subscale was used because it assesses only the maladaptive part of rumination, and it does not confound with depression (Treynor et al., 2003). In addition, rumination is a transdiagnostic factor that can account for symptoms in many disorders, such as depression and anxiety (Kring & Sloan, 2009; McLaughlin and Nolen-Hoeksema, 2011). Participants were asked to indicate what they generally do for each item on a 4-point Likert-type scale ranging from 1 (almost never) to 4 (almost always), with sample item as “think ‘what am I doing to deserve this?’”. The brooding subscale has 4 items in total, with good internal consistency (α = .79).

**Trait mindfulness.** Five Facet of Mindfulness Questionnaire (FFMQ; Baer et al., 2008) measures the general tendency towards mindfulness in daily life. The FFMQ captures different aspects of trait mindfulness, including observing, describing, acting with awareness, non-judging of inner experience and non-reactivity. Participants were asked to indicate how frequently or infrequently they have experienced each description on a 5-point Likert scale ranging from 1 (never or very rarely true) to 5 (very often or always true). There are 24 items in total. Higher average score indicates higher level of trait mindfulness. The internal consistency was good (α = .84).
**Psychological well-being/distress.** The Mental Health Inventory (MHI; Veit and Ware, Jr., 1983) measures various aspects of psychological distress, such as anxiety, depression and loneliness, and psychological well-being, such as positive affect and emotional ties. Participants answered each item on a 6-point Likert scale, and the options varied by the items. There are 38 items in total. Twenty-four items measured psychological distress, and fourteen items measured psychological well-being. The MHI was measured both at the beginning (time1) and at the end of the study (time2). Measurement for psychological distress and well-being both demonstrated high internal consistency at time 1 and 2 (α ranged from .91 to .94).

**Brief mindfulness practice.** The mindfulness group was asked to follow a video guided mindfulness meditation training that lasted for about 15 minutes. The video was obtained from the internet, and consisted of an audio of mindfulness practice script accompanied by a relaxing music and pictorial visual contents. The video was chosen because it covered most of the major steps in mindfulness meditation training, such as introduction of mindfulness, body relaxing, awareness of the mind, mantra repeating and releasing of negative thoughts (see appendix for transcribed audio text). The visual contents were used to draw participant’s attention to the task, rather than having them looking around at the experiment room. Participants were asked to follow the instructions to practice mindfulness meditation, for example, breathing, attention focusing, and non-reactivity.

**Music relaxation.** The control group (music) was presented with same visual contents accompanied by a collection of relaxing music, which also lasted for about 15 minutes. Music relaxation was used as control because it would help to demonstrate that the effect of mindfulness was different from the regular relaxation method (i.e. music). In a previous study
mindfulness training was associated with more psychological well-being when compared with music relaxation training (Roberts-Wolfe etc., 2012).

**Emotional stimuli task.** The participants were asked to watch a slide show of images that contains emotional stimuli. Images were taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). Thirty negatively valenced images and 30 positively valenced images were randomly selected based on IAPS rating. The order of the images was also be randomly assigned in the slide show. The slide show started with 10 neutrally valenced pictures so the participants became familiar with the task and so the primacy effect would be reduced. Another 10 neutrally valenced pictures were presented at the end of the slide show to reduce recency effect.

**Recognition memory test.** A memory test for the pictures from the slide show was administered. The task was another slide show consisting of 40 images with old images from the first slide show and new images (i.e., 10 negative appeared, 10 negative did not appear, 10 positive appeared, 10 positive did not appear). The participants were asked if they have seen the image or not. The slide show would not continue until the participants gave an answer. Ten neutrally valenced pictures appeared at the end but responses to the items were not included in data analysis. These images were included to make sure the participants would not leave the experiment still recalling disturbing pictures.

**Procedure**

Upon obtaining informed consent, participants first completed questions on demographic information, the Emotion Regulation Questionnaire, the Ruminative Responses Scale-Brooding, the Five Facet Mindfulness Questionnaire, and the Mental Health Inventory (time 1). Then they were instructed to either watch and learn mindfulness meditation through a 15 minutes video or
listen to relaxing music for 15 minutes. Following that was the emotional stimuli task and then the memory task which lasted about 10 minutes. Finally, the participants filled out the Mental Health Inventory again (time 2).
Results

Four subjects either were unable to finish the study or proceeded directly to the memory task after the images slide show without waiting for the experimenters to give proper instructions, thus were excluded from data analysis.

Descriptive statistics and correlations among cognitive reappraisal, expressive suppression, brooding, trait mindfulness, psychological distress and well-being can be found in Tables 1 and 2. Those who were excluded from the study did not differ on any of the measures from those who were included. Brooding was negatively correlated with trait mindfulness as expected, because its past events-oriented nature is considered an opposite to the present moment focused nature of mindfulness (Desrosiers et al., 2013). Brooding was also positively correlated with psychological distress and negatively correlated with psychological well-being. However, neither cognitive reappraisal nor expressive suppression was significantly correlated with the other variables.

Mindfulness and Psychological Well-being/Distress

To test whether psychological well-being and distress changed between time 1 and time 2, 2 ANCOVA tests were conducted separated for well-being and distress with time 2 psychological well-being/distress as dependent variable, time 1 as baseline covariate and group as between subjects variable. For psychological well-being, there was a significant main effect of group after controlling for time 1 psychological well-being, F(1,52)=4.33, p=.042, η²p=.08, with the mindfulness group having higher well-being score (Madjusted=3.63, SD=.06) than the control
group (M_{adjusted}=3.45, SD=.06). For psychological distress, there was a marginally significant main effect for group after controlling for time 1 distress, F(1,52)=2.89, p=.09, \eta^2_p=.05, with the mindfulness group (M_{adjusted}=2.61, SD=.05) having lower distress score than the control group (M_{adjusted}=2.73, SD=.06).

To test whether emotion regulation might moderate the effect of mindfulness training (vs. control), cognitive reappraisal and brooding were added to the previous model, respectively. No significant interaction effect between each of the three emotion regulation strategies (expressive suppression, cognitive reappraisal and rumination) and group was found: expressive suppression, F(1,50)=.003, p=.95, cognitive reappraisal, F(1,50)=1.20, p=.28, rumination, F(1,50)=1.76, p=.19.

**Mindfulness and Memory (Recognition)**

Signal detection theory (SDT) was utilized to quantify the memory test performance systematically for each type of image between the two groups (Stanislaw & Todorov, 1999). Four measures were calculated according to SDT: hit rates, false alarms, corrected recognition and nonparametric measures of sensitivity.

**Hit rates.** Hit rates were calculated as the proportion of correctly recognized old images within each experiment condition for image type (Stanislaw & Todorov, 1999). We hypothesized that mindfulness group would have a higher hit rates than the control group. A 2 (group) x 2 (valence) ANOVA was conducted. There was significant main effect of image type, F(1,53)=21.87, p<.001, \eta^2_p=.29, with higher hit rates for negative image (M=.93, SD=.09) than for positive image (M=.86, SD=.12), as shown in table 4. There was no significant main effect for group (M_{control}=.90, SD_{control}=.02; M_{mindful}=.89, SD_{mindful}=.02), F(1,53)=.25, p=.62, or image type and group interaction, F(1,53)=.01, p=.94, which did not support our hypothesis.
**False Alarms.** We hypothesized that the mindfulness group would have a higher false alarm rate for positive image because participants received mindfulness training should be preoccupied with positive stimuli and have their attention more biased towards positive stimuli. False alarms were calculated as the proportion of new items incorrectly recognized as old within each experiment condition for each image type (Stanislaw & Todorov, 1999). A 2 (group) x 2 (valence) ANOVA was conducted. There was significant main effect of image type, F(1,53)=46.04, p<.001, $\eta^2_p=47$, with higher false alarms for negative images (M=.15, SD=.13) compared with positive images (M=.04, SD=.06), as shown in table 4. No significant main effect of experiment condition was found (M_{control}=.07, SD_{control}=.02; M_{mindful}=.11, SD_{mindful}=.02), F(1,53)=2.46, p=.12, $\eta^2_p=.04$. No interaction effect between image type and group was found, F(1,53)=2.14, p=.12. However, there was a marginal significant effect of group when only looking at false alarm rates for positive image, F(1,53)=2.76, p=.04, $\eta^2_p=.05$, with the mindfulness group (M=.05, SD=.07) demonstrating more false alarms than control group (M=.02, SD=.04), as shown in table 4.

**Correct recognition.** Corrected recognition scores were calculated by subtracting the proportion of false alarms from the proportion of hits for each type of image, to test whether there was a difference in memory accuracy across each experiment condition (Stanislaw & Todorov, 1999). We expected no difference in corrected recognition for the two groups. Again, a factorial ANOVA with group as the between subjects variable and image type as the within subject variable was conducted. No significant main effect of image type or experiment condition, or interaction between image type and condition was found, p’s>.10.

**Sensitivity.** Nonparametric measures of sensitivity ($A'$) were calculated to examine the memory test performance (Stanislaw & Todorov, 1999). $A'$ was used because it was not affected
by response bias (i.e. a true measure of sensitivity). A factorial ANOVA with group as the between subjects variable and image type as the within subject variable indicated no significant effect of either image ($M_{positive}=95$, $SD_{positive}=.04$; $M_{negative}=94$, $SD_{negative}=.08$), $F(1,53)=2.00$, $p=.16$, $\eta^2_p=.04$, or group ($M_{control}=95$, $SD_{control}=.01$; $M_{mindful}=94$, $SD_{mindful}=.01$), $F(1,53)=1.55$, $p=.20$, $\eta^2_p=.03$, or imageXgroup interaction, $F(1,53)=.47$, $p=.50$, $\eta^2_p=.01$.

**Memory (recognition) and psychological distress/well-being**

To explore whether the difference in participants’ memory could have an effect on psychological distress/well-being, several ANCOVAs were conducted with either time 2 psychological well-being or distress as the dependent variable, time 1 psychological well-being or distress as the baseline covariate, group as the between subject variable and memory performance as the independent variable (Hit rate, False Alarms, Corrected Recognition, and Sensitivity). Only false alarm rate for positive images were marginally significant in predicting time 2 psychological well-being, controlling for time 1 psychological well-being, $F(1,52)=3.88$, $p=.05$, $\eta^2_p=.07$, so that higher false alarms for positively valenced images were related to higher score on psychological well-being. The effect of mindfulness was not undermined when false alarm rates for positive image were added in the model: without false alarm for positive image, $F(1,53)=6.44$, $p=.05$, $\eta^2_p=.11$; with false alarm for positive image, $F(1,52)=4.33$, $p=.04$, $\eta^2_p=.08$. Thus the mediational relationship with emotional memory mediating the relationship between mindfulness training and psychological well-being was not supported.
Discussion

Consistent with our hypotheses and many previous studies (Brown & Ryan, 2003; Carmody & Baer, 2008; Grossman, Niemann, Schmidt, & Walach, 2004), we found that receiving a 15 minutes brief mindfulness training increased perceived psychological well-being and lowered psychological distress. The findings provided further evidence of the effectiveness of brief mindfulness training, in particular, among college students.

Our second hypothesis was that mindfulness training would affect people’s emotional memory. Specifically, those who received mindfulness training should have more false alarms for positive images than those who did not receive mindfulness training. For the image recognition test, we found that negative images had both higher hit rate and false alarm rate than positive images for both mindfulness and control groups. This is not surprising, as previous literature has indicated that human brains are naturally more sensitive to emotionally negative stimuli (Cacioppo & Gardner, 1999; Delplanque, Lavoie, Hot, & Silvert, 2004; Huang & Luo, 2006). We also found a higher false alarm rate for positive images for mindfulness group compared to control group, although the difference was marginally significant. This supported our hypothesis that participants received mindfulness training have a bias towards positive stimuli. That is to say, participants tend to respond that they have seen a positively valenced image even if the image was not seen previously. It is particularly interesting because our study demonstrated that a person who received mindfulness training might have more positive memory, or at least believed he/she have more positive memory. According to Taylor and Brown (1998),
even positive illusion or positive unrealistic memories about positive events could contribute to better mental health outcome. Thus, the positive bias generated by mindfulness training might be the reason why it increases psychological well-being.

The general memory performance indicated by corrected recognition and sensitivity was not different between the two groups for either positive or negative image. However, this is not unexpected, as we did not propose any true memory difference for mindfulness group vs. control group.

The third hypothesis was that the difference in memory performance might contribute to the difference in psychological well-being/distress. Our results indicated that higher false alarm rate positively predicted time 2 psychological well-being after controlling for time 1 psychological well-being. So far, we have demonstrated that mindfulness meditation made participants have higher false alarm rate for positively valenced image, and that higher false alarm rate for positive image predicted higher psychological well-being.

Lastly, we examined the involvement of emotion regulation strategies in predicting psychological well-being/distress, but we did not find any significant interaction between emotion regulation strategy and mindfulness training.

**Limitations and Implications**

Although we established three links among all the targeted variables: mindfulness and psychological well-being, mindfulness and positive emotional memory, positive emotional memory and psychological well-being, we did not find significant results in how negative emotional memory or psychological distress were involved. Perhaps mindfulness training is only related to a boost of psychological well-being through more positive emotional memory rather than through less negative emotional memory.
Some of the relationships among the three variables were marginally significant. One reason could be the small sample size. Another reason was that most participants, no matter in the mindfulness or the control condition, had very good performance on the memory test (i.e., high hit rates), so large variations in participants’ memory performance results were not obtained. The memory test might be too easy for the participants, since it was a recognition test and that the test was followed immediately by the image slide show. In essence, the memory recognition test showed a ceiling effect. Future studies could increase the difficulty of the test by introducing a distraction task in between the stimuli exposure and recognition test, or lengthen the time span before the recognition test (e.g., Flores and Berenbaum, 2012).

Our findings implied that mindfulness meditation potentially altered people’s emotional memory with a bias towards positively valenced stimuli, and thus increased psychological well-being. It would be interesting for future studies to examine the specific processes that changed through mindfulness training, such as encoding and retrieval of memory. Moreover, the current study validated previous studies on the effectiveness of 15-minute brief mindfulness training. This should theoretically benefit college students who need a way to relieve their daily stress. However, the long-term effects of brief mindfulness training should also be examined in future studies.
Conclusion

The current study demonstrated that only receiving 15 minutes brief mindfulness training contributed to better mental health outcome, and that this process was at least partially explained by the increase of false alarms towards positive emotional memory. This study was one of the first to examine mechanisms by which mindfulness might make a difference in mental health indicators. We encourage future studies to keep exploring the mechanism of mindfulness meditation.
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Appendix

Mindfulness training script

“This meditation will instantly reduce the anxiety and fear that you are feeling right now. Make sure you are sitting comfortably, resting your hands gently on your legs, or whatever position that’s most comfortable for you. If you like, allow your eyes to gently close or focus them on an object in the room. Just let yourself become as comfortable and relaxed as possible. As you begin to settle in to this meditative state, focus your attention on your breathe. Feel the air move through your nasals as you simply let your breathe continue to flow, in and out. Ever so naturally. As you breathe, you may want to also turn your attention to the air in your nose, as you slowly push your belly in and out along with your breathe. Just gently focus on this now… As you are relaxed, feel so pleasant and comfortable, soon you’ll begin to speak some simple montras that will instantly help to calm your fear, anxiety or sense of panic… when you begin, you may have felt some uncomfortable feelings. You may feel some of these uncomfortable feelings still, perhaps a tightness in your chest or quicken up your heart beat. As you continue through this session, you will feel your heart rate settle in a wonderful sense of inner calm will slowly come over to you. As you hear these montras, slowly repeat them to yourself, one by one. You can say them in your mind, or if it helps, repeat them out loud, whichever is best for you. Dedicate one to full relaxed breathe to each montra and feel the powerful weight of each word as you repeat them. Continue to feel the air of your breathe, gently breathe in and out as we begin. Now either silently or out load, repeat after me. “As I breathe in and out, I am aware of my breathe… I am aware of my heart beat… I am aware of my body… As I breathe in and out, I am aware of the anxiety within me…. I am aware of my fears… I am aware of any tightness in my chest…As I breathe in and out, I am aware of my negative thoughts…Now I calm my negative thoughts…Now I release my negative thoughts…As I breathe in and out, I calm my anxiety, I calm my fear, I release the tightness in my chest…As I breathe in and out, I relax my minds, I relax my body, I slow down my thoughts…As I breathe in and out, I release my fears.. I become free with my anxiety, I become free of suffering… I find peace…As I breathe in and out, I let go, I let go… I let go…” Very good, you should now feel a wonderful sense of calm throughout your body and in your mind. You are now liberated and free. If you like you may listen once again, to tell yourself this montras and reinforce them. But for now, take a few more moments to breathe in and out, and relax in this moment of peace and stillness.”