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Mindfulness Meditation May Not Increase False-Memory and May Instead Protect from False-Memory Susceptibility

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Abstract A recent study demonstrated that a single session of mindfulness meditation increased false memories using the Deese-Roediger-McDermott (DRM) paradigm. This purportedly resulted from mindfulness meditation inducing nonjudgmental observation of experience that contributed to failure to distinguish internally generated from externally presented information. We sought to replicate these results and extend them by warning half of the participants that the DRM task would elicit false memories. We hypothesized that we would see a lower incidence of false memories in the mindfulness induction–warning group consistent with previous findings regarding control of attention. In two experiments, we found results inconsistent with our hypotheses: in Experiment 1, the mindfulness induction did not lead to a greater number of false memories, nor did the warning interact with the induction; in Experiment 2, groups did not differ in the number of false memories, and the mindfulness meditation group significantly decreased false memories after the mindfulness induction. We propose that it may be too early to conclude that mindfulness meditation increases susceptibility to false memory.

Keywords Deese-Roediger-McDermott (DRM) paradigm · Mindfulness induction · False memory

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Introduction

Mindfulness meditation—attending to one's present experience in a nonjudgmental and non-elaborative way—is typically associated with many positive outcomes, including reduced stress, anxiety, fatigue, depression and substance abuse, and improved mood, affect, and cognitive performance (Chiesa et al. 2011). A recent example contrary to the above (Wilson et al. 2015) was that mindfulness meditation decreased the ability to distinguish externally presented from internally generated information, resulting in an increased susceptibility to false memories.

False memories—remembering an event that never actually occurred or remembering an event differently from how it occurred—can be elicited and indexed in numerous ways. In the Deese-Roediger-McDermott (DRM) paradigm, participants are presented a list of semantically associated words that all have an unpresented word in common (known as the critical item; Roediger and McDermott 1995). This unpresented critical item is presumably activated by each presentation of an associated word, and hence likely to be falsely recalled as being previously presented. For example, being shown the words *rest, nap, snooze, dream, bed, alarm, pillow* is believed to activate the unpresented critical item *sleep* via spreading activation; participants are then likely to recall *sleep* as one of the presented words despite it never being externally presented. Recent studies have found that simple manipulations may increase or decrease the likelihood of falsely recalling the critical item: mindfulness meditation was found to increase the likelihood of false memories (Wilson et al. 2015) whereas providing a warning about the DRM paradigm to participants who could better control their attention was found to decrease the likelihood of false memories (Watson et al. 2005).

In Wilson et al.'s (2015) first experiment, participants were shown either a 15-min guided mindfulness or mind wandering induction video, and then completed one 15-word DRM list. In the second experiment, participants completed six 15-word DRM lists prior to induction, then were shown either the guided mindfulness or mind wandering induction video, and then completed an additional six 15-word DRM lists. In both experiments, the mindfulness group recalled significantly more critical items than the mind wandering group on the post-induction lists, whereas both groups in both experiments did not differ on the number of intrusions (non-presented nor non-critical items recalled) or correct recalls. In the second experiment, groups did not differ on the number of critical item recalls for the pre-induction lists, and the mindfulness group significantly increased their number of critical item recalls from pre- to post-induction lists. For their third experiment, Wilson et al. presented participants one word from each pair of 100 strongly associated word pairs, after which participants viewed presented or unpresented words from the pairs they had previously seen and indicated whether words were new or old. Participants were then shown the guided mindfulness induction video and completed the strongly associated word pair task again with a new set of 100 strongly associated word pairs. Following the mindfulness induction, participants were significantly less accurate in distinguishing new from old words and had a significantly higher number of false alarms compared to their pre-induction word pairs.

Wilson et al. (2015) attributed this apparent increase in false memory susceptibility following mindfulness meditation to the nonjudgmental and non-elaborative nature of such practice. They posited that the lack of cognitive operations (e.g., not elaborating on word meanings or actively encoding to enhance recall) during word presentation would preclude any trace record being added to internally generated information that came to mind (e.g., the critical item). During recall, participants would then be missing important cues to remember that such information was internally generated and better distinguish it from the words that were externally presented.

One method of reducing the recall of critical items was investigated by Watson et al. (2005). In two experiments, Watson et al. examined individual differences in working memory capacity (WMC) and susceptibility to false memories in the DRM paradigm. In their first experiment, they compared individuals with high vs low working memory spans and whether the presence or absence of a warning that the DRM task elicited false memories impacted recall of critical items. They observed that high span individuals provided with a warning recalled significantly fewer critical items than did low span individuals, though the two span groups did not differ in critical item recalls absent a warning. The authors replicated this finding as part of a more complex second experiment. Using the Kane and Engle (2002, 2003) controlled attention WMC framework, Watson et al. speculated that high span participants were better able to control their attention to actively maintain task goals (i.e., being aware that the list would elicit recall of an unpresented word that was likely to be brought to mind) and to avoid interference and habit (i.e., automatic activation of unpresented critical items in associate networks).

Although Wilson et al. (2015) found that a mindfulness induction led to a potentially adverse effect, the majority of research on mindfulness meditation has shown salutary benefits of such practice. In particular, mindfulness meditation has been shown to improve performance on measures of basic and complex cognitive ability. Numerous mechanisms and explanations for such improvement have been offered; the studies described below purport such benefits emanating from participants learning to control their attention by continually focusing on the present moment.

Zeidan et al. (2010) demonstrated that mindfulness meditation significantly improved various measures of cognitive ability whereas an active control group did not improve. Specifically, four brief mindfulness meditation sessions significantly improved various measures of working memory and executive functioning from pretest to posttest, whereas an active control group did not improve. Germaine to the current study, most working memory models posit the importance of attentional control in regulating higher - order cognition (e.g., Baddeley 2012; Cowan 1999; Kane and Engle 2003). In a more extended training, Mrazek et al. (2013) observed that mindfulness meditation significantly improved focus and performance on two measures of cognitive ability. Specifically, a 2-week course in mindfulness meditation significantly improved performance on measures of working memory and reading comprehension and significantly reduced instances of mind wandering, whereas an active control group did not demonstrate such improvement.

Similarly, Morrison et al. (2014) found that mindfulness-trained college students exhibited improved performance on a measure of sustained attention and reduced mind wandering compared to students receiving no training. Here, mindfulness training referred to exercises intended to cultivate a present-centered, attentive, and non-reactive mental mode, as would be practiced during mindfulness meditation. Morrison et al. observed that a student cohort provided with 7 hr of mindfulness training over a 7-week interval during an academic semester were more accurate and demonstrated less intra-individual reaction time variability on a sustained attention task following mindfulness training than before it, whereas a wait-list control group was less accurate, exhibited more intra-individual reaction variability, and had greater self-reported mind wandering compared to their initial performance 7 weeks earlier. Furthermore, the mindfulness-training cohort was significantly more accurate on the sustained attention task with less self-reported mind wandering than the wait-list control group following training. It should be noted that this study included two working memory measures: the control group had stagnant performance whereas the mindfulness-training group improved performance following training but did not reach statistical significance (Morrison et al. 2014).

Zeidan et al. (2010), Mrazek et al. (2013), and Morrison et al. (2014) posited that mindfulness meditation might improve the ability to control one's attention—reflected here in improved performance on measures of cognitive ability—after brief training. Attentional improvement following mindfulness meditation has been observed after only 8 min: Mrazek et al. (2012) demonstrated that 8 min of mindful breathing led to significantly more accurate and less variable responses on a sustained attention task compared to passive reading or relaxation groups. As mindfulness meditation incorporates awareness of the present moment and the direction of one's attention to a specific aspect of experience, participants may acquire the ability to direct their attention where intended, sustain attention on desired aspects of experience, notice when the mind has wandered away from its intended aspect of experience, and reorient attention back to the intended aspect of experience upon noticing distraction.

In sum, susceptibility to false memories may increase following mindfulness meditation, but may decrease if one can control their attention and are provided a warning to be wary of false memories. Separately, mindfulness meditation is thought to improve control of one's attention. Therefore, it may be possible to decrease susceptibility to false memories following mindfulness meditation if meditators are given a warning to be wary of false memories.

Experiment 1

The current investigation sought to replicate previously reported effects of mindfulness meditation on false memories and examine the interaction of mindfulness meditation and a false memory warning. In Experiment 1, we sought to replicate Wilson et al.'s (2015) findings that mindfulness meditation increased false memories and extend them by incorporating the DRM warning manipulation of Watson et al. (2005). We hypothesized that we would replicate Wilson et al.'s findings that the mindfulness meditation group would have a higher incidence of unpresented critical item recalls than the mind wandering group when not given a warning about the DRM paradigm. We further hypothesized an interaction between the mindfulness meditation group and the DRM warning: mindfulness meditators would significantly reduce the incidence of unpresented critical item recalls if provided a warning that the DRM paradigm elicits such false memories.

We suspected this based on the Watson et al. (2005) study, where participants with larger working memory capacities—more precisely, participants better able to control their attention—had lower recall rates of unpresented critical items than participants with smaller working memory capacities—more precisely, participants less able to control their attention—when provided a warning about the DRM paradigm. As mindfulness meditation has been demonstrated to improve performance on measures of working memory reliant on attentional control (Mrazek et al. 2013; Zeidan et al. 2010) as well as other tasks reliant on the ability to sustain attention (Morrison et al. 2014; Mrazek et al. 2012), we believed that mindfulness meditation may have an effect on control of attention. In the current study, this would result in similar effects as the Watson et al. (2005) experiments: improved control of attention following mindfulness meditation should interact with a warning about the DRM paradigm to significantly reduce false memories. Lastly, we hypothesized that the mindfulness and mind wandering groups would not differ on number of intrusions (i.e., words recalled that were not presented nor critical items) and number of correct recalls, consistent with Wilson et al.'s (2015) findings.

Method

Participants

Two hundred and two undergraduates at a large Midwestern university participated for course credit. Upon entering our lab, they were randomly assigned to one of four groups: mindfulness induction with DRM warning (n = 49), mindfulness induction without DRM warning (n = 52), mind wandering induction with DRM warning (n = 51), and mind wandering induction without DRM warning (n = 50).

Procedure

Participants sat in one of four computer stations in a large sound attenuated laboratory. Six (pre-induction) DRM word lists from a set of 24 word lists (aee Appendix Table 4 for lists) were presented in random order and without replacement. Lists consisted of 15 associated words with an unpresented word in common (i.e., the critical item). Each word was presented in the center of the computer screen for 1.5 s. After viewing each list, participants immediately typed in as many words as they could remember.

After the six lists were completed, participants then received a 15-min mindfulness induction or a 15-min mind wandering induction. We used the same mindfulness and mind wandering induction videos as Wilson et al. (2015). During the mindfulness induction, participants listened to a guided focused-breathing exercise recorded by Marilee Bresciani Ludvik at the Rushing to Yoga Foundation, based on a script by Arch and Craske (2006), adapted from Kabat-Zinn (1990). A stationary plant was displayed during the video. During the mind wandering induction video, also used by

Wilson et al. and recorded by Marilee Bresciani Ludvik, participants were instructed to not focus on anything in particular and to think about whatever came to mind. A flickering candle was displayed during the video.

Following the induction, participants completed a new set of six randomly assigned (without replacement) and presented post-induction DRM word lists, none of which were presented in the pre-induction DRM word lists. Each word was presented in the center of the computer screen for 1.5 s. After viewing each list, participants immediately typed in as many words as they could remember. Prior to post-induction lists, participants in the no warning groups were informed that they would again be presented with a list of words and asked to recall them later and to remember as many words as they could. Participants in the warning groups were given the same instructions and informed that: "The lists are designed to make you think you saw a word you did not. ONLY RECALL THE WORDS YOU ACTUALLY SAW."

Following the last free recall attempt, participants completed a word recognition task. During the recognition task, participants saw the critical items and three words from each of the 24 possible lists. Therefore, participants were presented with the 12 critical items related to the lists they saw, three words from each of those lists (36 words total) and 48 words not previously seen. Each was presented in the center of the computer screen under the question "Was this word presented earlier?" Underneath the word was the prompt, "Press 1 for yes. Press 2 for no." The recognition task was self-paced.

Data Analyses

Data were analyzed using the IBM Statistical Package for the Social Sciences (SPSS) version 22.0. To investigate the effects of mindfulness vs mind wandering inductions and the warning vs no warning groups, general linear model analyses with repeated measures analysis of variance were conducted with time (pre-induction vs post-induction) as a within-subject factor and two between-subject factors: mindfulness (mind wandering vs mindfulness) and warning (warning vs no warning). Dependent variables of interest pertaining to the recall portion of the DRM task were the number of critical items recalled (i.e., false memories), the number of correctly recalled presented items, the number of intrusions (i.e., recalled words that were not presented nor critical items), and the number of total responses. Dependent variables of interest pertaining to the recognition task were the number of unpresented critical items recognized from previously presented DRM word lists (i.e., false memories). We also conducted two 2 (warning vs no warning) × 2 (mindfulness vs mind wandering) factorial ANOVAs for reaction time for correct and incorrect responses during the recognition task.

Results

Table 1 presents the means and standard deviations of the proportion of critical item, correct, and intrusion recalls by group. Recall that our primary goal was to test the effects of the mindfulness induction as compared to the mind wandering induction on recall of critical items in the DRM paradigm. To ensure that there were no differences in group performance prior to the induction, we tested for group differences in the number of critical items recalled prior to the induction. We found that the participants in the four different groups did not differ, F (3, 201) = 1.24, p = .30.

The proportion of critical item recalls (pre-induction and post-induction) ranged from .57 to .86 (Appendix Table 4 includes the proportion of critical item recalls for each list in Experiment 1). We conducted an analysis to determine if there were any differences in critical item recall due to list effects. The analysis did not indicate any significant item effects.

False Memories (Critical Items Recalled)

Figure 1 presents the mean proportion of critical items recalled before and after the induction by induction group and warning. To investigate the effects of mindfulness vs mind wandering inductions and the warning vs no warning on the DRM task performance, using proportion of critical items recalled as the dependent variable, we conducted a repeated measures ANOVA with time (pre-induction vs post-induction) as a within-subject factor and two between-subject factors: mindfulness (mind wandering vs mindfulness) and warning (warning vs no warning). The results indicated a non-significant effect of time, $F < 1$. Thus, as a whole, participants' recall of critical items did not change from pre-induction to post-induction. The interaction between mindfulness and time was also non-significant, $F < 1$. However, the interaction between warning and time was significant, F (1, 198) = 4.62, p = .03, MS_e = .033, η_p^2 = .023, indicating that participants in the warning groups recalled fewer critical items following the induction than they did prior to the induction, whereas those in the no warning groups recalled more critical items following the induction (see Fig. 1). The three-way interaction (time × warning × induction) was not significant, $F < 1$.

Correct Recalls of Presented Items

As in previous research (Wilson et al. 2015), we examined whether there were differences in correctly recalled words. To investigate the effects of the mindfulness vs mind wandering inductions and the warning vs no warning on correct recalls, we again conducted a repeated measures ANOVA, in this case using proportion of correctly recalled items as the dependent variable, time as a within-subject factor and the two between-subject factors: mindfulness (mind wandering vs

Table 1 Experiment 1: means and standard deviations of proportion of critical item, correct, and intrusion recalls

		Critical items		Correct recalls		Intrusions	
		Pre-induction	Post-induction	Pre-induction	Post-induction	Pre-induction	Post-induction
Mind wandering	No warning	.269 (.214)	.288 (.227)	.419 (.111)	.476 (.121)	.343 (.305)	.401 (.382)
	Warning	.303 (.236)	.240 (.194)	.448 (.111)	.458 (.108)	.438 (.435)	.418 (.521)
Mindfulness	No warning	.214 (.233)	.262 (.213)	.444 (.109)	.491 (.127)	.439 (.480)	.412 (.359)
	Warning	.261 (.236)	.235 (.206)	.431 (.093)	.454 (.121)	.539 (.442)	.422 (.481)

mindfulness) and warning (warning vs no warning). The results indicated a significant within-subject effect of time, F (1198) = 29.58, MS_e = 1.02, p < .001, η_p^2 = .13. Thus, as a whole, participants correctly recalled a greater proportion of presented items post-induction compared to pre-induction. The interaction between mindfulness and time was non-significant, F < 1. However, as with critical items, the interaction between warning and time was again significant, F (1, 198) = 7.90, MS_e = 1.02, p = .005, η_p^2 = .38. The interaction indicated that those in the warning groups did not display the same increase in correct recalls as those in the no warning groups following the induction. The three-way interaction (time × warning × induction) was not significant, F < 1.

Number of Intrusions and Total Words

We conducted a repeated measures ANOVA, in this case using the number of intrusions as the dependent variable, time as a within-subject factor and the two between-subject factors: mindfulness (mind wandering vs mindfulness) and warning (warning vs no warning). The results indicated a significant within-subject effect of time, F (1198) = 36.49, MS_e = 3.34, p < .001, η_p^2 = .16. Thus, as a whole, participants produced fewer intrusions post-induction compared to pre-induction. The interaction between mindfulness and time approached significance, F (1198) = 3.59, p < .059, η_p^2 = .02. However, as with critical items and correct recalls, the interaction between warning and time was again significant, F (1, 198) = 4.94, p = .027, η_p^2 = .02. The interaction indicated that those in the warning groups did not display the same number of intrusions as those in the no warning groups following the induction. The three-way interaction (time × warning × induction) was not significant, F < 1.

Finally, to determine if participants in the warning groups simply chose to withhold recall responses, we conducted a repeated measures analysis with total number of words produced as the dependent variable. The results indicated a significant within-subject effect of time, F (1198) = 9.87, MS_e = 40.36, p < .002, η_p^2 = .05. Thus, as a whole, participants produced more words following the induction than prior to the induction. However, the interaction between warning and time was again significant, F (1, 198) = 11.72, p < .001, η_p^2 = .06, suggesting that participants that were warned did not demonstrate the same increase in production as those not warned. The interaction between mindfulness and time was not significant, nor was the three-way interaction (time × warning × induction) significant, F's < 1.

Recognition Task

Table 2 presents the means and standard deviations of hit rate (proportion of items correctly identified as presented) and false alarm (proportion of critical items identified as presented) by list (pre-induction and post-induction). To investigate

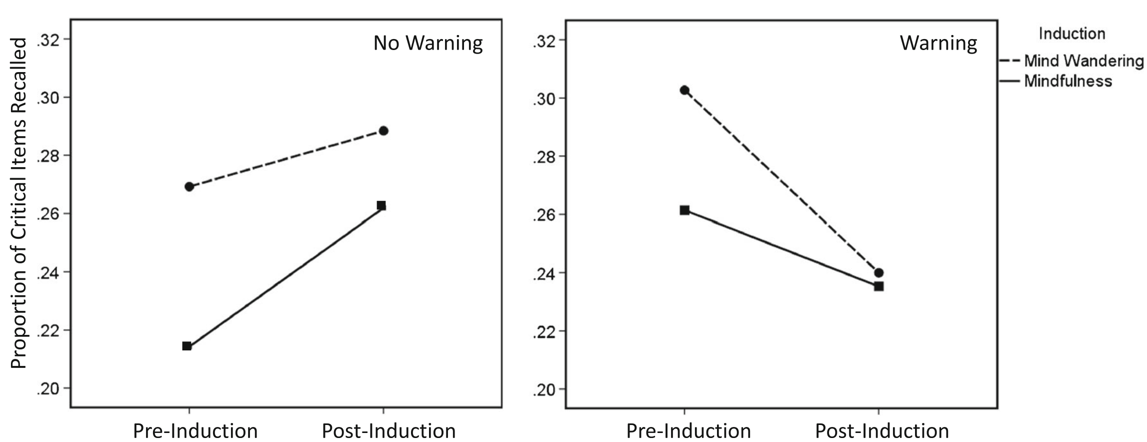

Fig. 1 Mean proportion of critical items recalled before and after the induction by induction and warning in Experiment 1

Table 2 Experiment 1: means and standard deviations of hit rate and false alarm rate by induction and warning

		Hit rate		False alarm rate	
		Pre-induction	Post-induction	Pre-induction	Post-induction
Mind wandering	No warning	.735 (.149)	.794 (.113)	.079 (.033)	.107 (.052)
	Warning	.731 (.157)	.810 (.114)	.076 (.033)	.079 (.023)
Mindfulness	No warning	.782 (.126)	.823 (.109)	.070 (.030)	.111 (.064)
	Warning	.739 (.159)	.808 (.141)	.083 (.048)	.085 (.051)

the effects of the inductions and the warning on the recognition portion of the DRM task performance, we conducted a repeated measures ANOVA with time (presented pre-induction vs post-induction) as a within-subject factor and two between-subject factors: mindfulness (mind wandering vs mindfulness) and warning (warning vs no warning), and false alarms as the dependent variable. The results indicated a main effect of time, suggesting that participants produced more false alarms on critical items from post-induction lists compared to pre-induction lists, F (1, 197) = 68.39, $p < .001$, $MS_e = .033$, $\eta_p^2 = .256$. Thus, as a whole, participants' false recognition of critical items increased from pre-induction to post-induction. However, the results also suggested a main effect of warning. Participants in the warning groups committed fewer false alarms on post-induction critical items than those in the no warning condition, F (1, 197) = 6.83, $p < .010$, $MS_e = 5.22$, $\eta_p^2 = .033$. The interaction between warning and time was also significant, F (1, 197) = 34.48, $p < .001$, $MS_e = 1.47$, $\eta_p^2 = .149$, indicating that participants in the warning groups identified fewer critical items from the post-induction lists than pre-induction lists, whereas those in the no warning groups identified more critical items as presented from post-induction lists than pre-induction lists. All other interactions were not significant, *F's* < 1. This replicated the findings of the recall task for critical items. We also conducted two 2 (warning vs no warning) × 2 (mindfulness vs mind wandering) ANOVAs on reaction time: one for correct responses and one for incorrect responses. The results of both ANOVAs were non-significant.

Discussion

The results of Experiment 1 did not corroborate the previous evidence that false memory susceptibility increases after mindfulness meditation. The results indicated that warning participants of potentially recalling critical items reduced the likelihood of false recalls. However, the results indicated that neither the mindfulness induction nor mind wandering induction interacted with a warning to reduce the number of critical items falsely recalled or increase the number of correct recalls in comparison to the other induction. One limitation of Experiment 1 was the lack of a true control group. The null results regarding the mindfulness induction not leading to more falsely recalled critical items compared to the mind wandering induction may be due to both inductions leading to a state in which participants are equally likely to falsely recall the critical items. In the second experiment, we attempted to determine if the mindfulness or mind wandering inductions may affect the results of the DRM paradigm compared to a control group.

Experiment 2

Method

Participants

Seventy-five undergraduates participated for course credit. Upon entering our lab, they were randomly assigned to one of three groups: mindfulness induction, mind wandering induction, or a control group (25 participants in each group).

Procedure

Participants sat in one of four computer stations in a large sound attenuated laboratory. Six (pre-induction) DRM word lists were randomly selected (without replacement) from the same set of 24 word lists from Experiment 1 and were presented in random order. Each word was presented in the center of the computer screen for 1.5 s. After viewing each list, participants immediately typed in as many words as they could remember.

After the six lists were completed, participants in the mindfulness and mind wandering induction groups received the same inductions as Experiment 1. Participants in the control group were instructed to complete word search puzzles and were given 15 min to work on multiple puzzles. Following the inductions or puzzles, participants completed a new set of six randomly assigned (without replacement) and presented post-induction DRM word lists, none of which were presented in the pre-induction DRM word lists. Each word was presented in the center of the computer screen for 1.5 s. After viewing each list, participants immediately typed in as many words as they could remember.

Data Analysis

Data were analyzed using the IBM Statistical Package for the Social Sciences (SPSS) version 22.0. To investigate the effects of induction of false memories, general linear model analyses with repeated measures analysis of variance were conducted with a 3 (group: mindfulness, mind wandering, control) × 2 (time: pre-induction vs post-induction) design. Dependent variables of interest were the number of critical items recalled, the number of correctly recalled presented items, and the number of intrusions.

Results

Table 3 presents the means and standard deviations of the proportion of critical item, correct, and intrusion recalls by group. Recall that our primary goal was to test the effects of the mindfulness induction as compared to the mind wandering induction and control group on recall of critical items in the DRM paradigm. To ensure that there were no differences in group performance prior to the induction, we tested for group differences in the number of critical items recalled prior to the induction. We found that the participants in the three different groups did not differ, F (2, 70) = 1.21, p = .30.

False Memories (Critical Items Recalled)

To examine the effect of induction on false memories, we performed a 3 (group: mindfulness, mind wandering, control) × 2 (time: pre-induction vs post-induction) repeated measures ANOVA. Results indicated a significant within-subject effect of time, with subjects recalling fewer critical items after the induction, F (1, 70) = 4.84, p = .03, partial η^2 = .07, but no interaction, F (2, 70) = 1.65, p = .20, η^2 = .04. There were no significant group differences in the number of critical items recalled following the induction, F (2, 70) = 2.21, p = .12. Although the results of the repeated measures ANOVA did not indicate a significant interaction, the data presented in Table 3 suggest that the effect of time was greater in the mindfulness induction group. We completed a series of t tests to explore this result. We caution the reader that these analyses are purely exploratory and that the results must be interpreted as such. Participants in the mindfulness group were significantly less likely to falsely recall the critical item after the induction than before, t(24) = 3.02, p = .006, Cohen's d = 1.23, CI = [.25, 1.34]. Although numerically different, there were no significant differences between pre- and post-induction critical item recalls for the participants in the mind wandering group, t(23) = .74, p = .47 Cohen's d = .30, CI = [−.38, .79] or differences between pre- and post-induction critical item recalls in the control group, t(23) = .37, p = .72, Cohen's d = .15, CI = [−.58,.83].

Correct Recalls of Presented Items

To explore the effect of induction on correct recalls, a 3 (group: mindfulness, mind wandering, control) × 2 (time: pre-induction vs post-induction) repeated measures ANOVA was conducted using proportion of correctly recalled items as the dependent variable. Results indicated a significant within-subject effect of time, F (1, 70) = 13.63, p < .001, partial η^2 = .16, and a significant interaction, F (2, 70) = 6.10, p = .004, η^2 = .15, but no effect of group, F < 1. Table 3 indicates that the interaction was driven by the increase in correct recalls for the mind wandering group, t(23) = 4.81, p < .001, CI [3.94, 9.88], and the lack of significant differences for the mindfulness and control groups.

Number of Intrusions

Finally, we conducted a repeated measures ANOVA on word intrusions. Results indicated a significant within-subject effect of time, F (1, 70) = 4.13, p = .046, partial η^2 = .06 and an effect of group, F (2, 70) = 5.15, p = .008, partial η^2 = .13. Post hoc analyses suggest that group differences were the result of those in the mind wandering induction reporting a greater number of intrusions at both the pre- and post-induction (see Table 3). However, participants in the mind wandering group recalled more intrusions after the induction than both the mindfulness and control groups F (2, 70) = 4.89p = .010, partial η^2 = .94 (Tukey's HSD post hoc tests were significant at p = .03 and p = .02, respectively). In terms of percentage change, the mindfulness group reported 12% fewer intrusions, the control group 35% fewer, and the mind wandering group only 4% fewer intrusions.

Table 3 Experiment 2: means and standard deviations of proportion of critical item, correct, and intrusion recalls

	Critical items		Correct recalls		Intrusions	
	Pre-induction	Post-induction	Pre-induction	Post-induction	Pre-induction	Post-induction
Mind wandering	.360 (.271)	.326 (.238)	.402 (.093)	.472 (.103)	.713 (.554)	.686 (.607)
Mindfulness	.333 (.215)	.200 (.180)	.499 (.118)	.432 (.123)	.400 (.329)	.353 (.392)
Control	.260 (.193)	.243 (.220)	.404 (.092)	.411 (.078)	.487 (.375)	.319 (.286)

Discussion

Contrary to Experiment 1, results of Experiment 2 suggested that the mindfulness meditation induction led to fewer critical item recalls after the induction than prior to the induction. Further, on average, all participants recalled fewer critical items following the induction, but the source of the main effect lied within the mindfulness induction group.

General Discussion

The current investigation sought to replicate Wilson et al.'s (2015) findings that false memories (i.e., critical item recalls) increased following mindfulness meditation using the DRM paradigm. The current work also sought to extend these findings by incorporating a warning that the DRM paradigm elicits false memories (Watson et al. 2005) to examine if the warning interacted with the mindfulness induction. Finally, one of the current experiments extended Wilson et al.'s findings by incorporating an active control group to contrast the mindfulness and mind wandering inductions' effects on DRM performance.

In contrast to Wilson et al.'s findings, we did not observe an increase in false memories (i.e., critical item recalls) following mindfulness meditation, nor did we observe significant differences in false memories between mindfulness, mind wandering, or control groups. Regarding the effect of a warning about the DRM paradigm, this did not interact with mindfulness nor mind wandering in terms of critical item recalls. We did observe that participants who were given a warning significantly reduced their number of critical item recalls. One interesting finding was a statistically significant decrease in critical item recalls following mindfulness meditation in our second experiment. Further, in Experiment 1, we did not observe group differences or within-subject changes regarding intrusions or correct recalls, but did find within-subject changes for the mind wandering group in Experiment 2.

The current investigation observed results inconsistent with Wilson et al.'s (2015) findings. Whereas they concluded that mindfulness meditation increased susceptibility to false memories, our results do not support this. In fact, not only were there no differences between mindfulness and comparison groups, we also observed a significant reduction in false memories following mindfulness meditation in one of our experiments. The differences between the results of the current work and Wilson et al. are likely not due to differences in design. The present investigation utilized two experiments most similar to Wilson et al.'s Experiment 2, and very similar to their Experiment 1. Both their and our studies utilized similar numbers of undergraduate participants, identical mindfulness and mind wandering inductions, and identical protocols. Therefore, the present results did not differ from Wilson et al. because of different populations, methods, or materials.

Limitations

There are several potential reasons why the present results differed from Wilson et al. (2015). First, it is possible that our results differed from Wilson et al. because we used different although similar DRM word lists. The word lists used in the current investigation and those used by Wilson et al. were drawn from two overlapping sets of stimuli. Our word lists came from Roediger and McDermott (1995), whereas Wilson et al. lists came from Roediger et al. (2001). Twenty-four of Roediger et al.'s (2001) 55 lists were the 24 lists used in Roediger and McDermott (1995), which were the 24 lists used in our study. Wilson et al. (2015) used specific DRM word lists in Experiments 1 and 2, which highly overlapped with our word lists. For example, Wilson et al. used the critical item *trash* in Experiment 1, critical items *mountain, music, thief, doctor, cold,* and *needle* as pre-induction lists, and *lamp, trash, slow, wish, foot,* and *window* as post-induction lists in Experiment 2 (with pre- and post-induction lists presented in random order). All of the above lists were potentially present in our experiments as pre- and post-induction lists with the exceptions of *trash*, *lamp*, and *wish*. Recall that in our experiments, word lists presented to participants as pre- and post-induction lists were randomly sampled without replacement from the 24 possible words lists. We chose such a design to avoid stimuli affects and to generalize Wilson et al.'s findings to a broader set of commonly used DRM word lists [for norming and probability of critical item recall in sample populations, we direct the reader to Roediger et al. (2001) and Stadler et al. (1999) for probabilities of false alarms].

A second potential reason that our results differed from Wilson et al. (2015) is that the effects of mindfulness meditation on false recall are not robust, leading to variable results. Wilson et al. used three different experiments with various methods, two of which incorporated the DRM paradigm (i.e., Experiment 1 with one DRM list at post-induction, Experiment 2 with six DRM lists at pre-induction and six DRM lists at post-induction). Both of our experiments used six DRM lists at pre-induction and six DRM lists at post-induction. Wilson et al. observed that critical item recall increased following mindfulness meditation, whereas we found no increase in critical item recall following mindfulness meditation. In fact, Experiment 2 of the present work observed a significant decrease in critical item recall following the mindfulness induction. Given the variable nature of these results, no consistent pattern appears regarding critical item recall following mindfulness meditation. Future work could explore this further, potentially including experienced mindfulness meditation practitioners and incorporating multiple measures of false memories. If, as Wilson et al. propose, the nonjudgmental nature of mindfulness practice decreases cognitive operation tags that can distinguish internally generated phenomena, then experienced practitioners should exhibit higher levels of false memories than matched controls.

A third potential reason for the present results differing from Wilson et al. (2015) concerns the extent of mindfulness meditation practice utilized by both investigations. If a relationship does exist between mindfulness meditation and false memories, it could be the case that one 15-min session with naïve practitioners is not enough practice to truly observe mindfulness meditation's effects on false memory. In experimental and clinical contexts, mindfulness meditation is typically practiced for longer and more frequent sessions. For example, Zeidan et al. (2010) found cognitive benefits of mindfulness meditation following four 20-min sessions. Mindfulness-based stress reduction (MBSR) incorporates an 8-week training and practice schedule with multiple guided and varied forms of mindfulness meditation practice. Long-term practitioners have reported hundreds to thousands of hours of practice over years and decades. Therefore, effects of mindfulness meditation may take longer than one 15-min session to manifest. If a relationship between mindfulness meditation and false memory does exist, future work using longer-term training or more experienced practitioners as well as multiple measures of false memory would be better suited to investigate such an association.

Author Contributions MB: designed the study, executed the study, assisted with the data analyses, wrote the introduction and general discussion parts of the paper. CW: designed the study, analyzed the data, wrote the method and results parts of the paper.

Compliance with Ethical Standards All procedures performed in these experiments with human participants were in accordance with the ethical standards of the American Psychological Association and approved by the institutional review board. Informed consent was obtained from all individual participants in the study.

Conflict of Interest Michael Baranski declares that he has no conflict of interest. Christopher Was declares he has no conflict of interest.

Appendix

Table 4 Experimental Sstimuli used in Eexperiments 1 and 2

Critical Items	anger (.69)	black (.78)	bread (.77)	chair (.70)	cold (.65)	doctor (.79)	foot (.57)
Word Lists	mad	white	butter	table	hot	nurse	shoe
	fear	dark	food	sit	snow	sick	hand
	hate	cat	eat	legs	warm	lawyer	toe
	rage	charred	sandwich	seat	winter	medicine	kick
	temper	night	rye	couch	ice	health	sandals
	fury	funeral	jam	desk	wet	hospital	soccer
	ire	color	milk	recliner	frigid	dentist	yard
	wrath	grief	flour	sofa	chilly	physician	walk
	happy	blue	jelly	wood	heat	ill	ankle
	fight	death	dough	cushion	weather	patient	arm
	hatred	ink	crust	swivel	freeze	office	boot
	mean	bottom	slice	stool	air	stethoscope	inch
	calm	coal	wine	sitting	shiver	surgeon	sock
	emotion	brown	loaf	rocking	arctic	clinic	smell
	enrage	gray	toast	bench	frost	cure	mouth
Critical Items	fruit (.86)	girl (.80)	high (.82)	king (.78)	man (.80)	mountain (.64)	music (.66)
Word Lists	apple	boy	low	queen	woman	hill	note
	vegetable	dolls	clouds	England	husband	valley	sound
	orange	female	up	crown	uncle	climb	piano
	kiwi	young	tall	prince	lady	summit	sing
	citrus	dress	tower	George	mouse	top	radio
	ripe	pretty	jump	dictator	male	molehill	band
	pear	hair	above	palace	father	peak	melody
	banana	niece	building	throne	strong	plain	horn
	berry	dance	noon	chess	friend	glacier	concert

Table 4 (continued)

	cherry	beautiful	cliff	rule	beard	goat	instrument
	basket	cute	sky	subjects	person	bike	symphony
	juice	date	over	monarch	handsome	climber	jazz
	salad	aunt	airplane	royal	muscle	range	orchestra
	bowl	daughter	dive	leader	suit	steep	art
Critical Items	needle (.66)	river (.81)	rough (.70)	sleep (.65)	slow (.83)	soft (.77)	spider (.83)
Word Lists	thread	water	smooth	bed	fast	hard	web
	pin	stream	bumpy	rest	lethargic	light	insect
	eye	lake	road	awake	stop	pillow	bug
	sewing	Mississippi	tough	tired	listless	plush	fright
	sharp	boat	sandpaper	dream	snail	loud	fly
	point	tide	jagged	wake	cautious	cotton	arachnid
	prick	swim	ready	snooze	delay	fur	crawl
	thimble	flow	coarse	blanket	traffic	touch	tarantula
	haystack	run	uneven	doze	turtle	fluffy	poison
	thorn	barge	riders	slumber	hesitant	feather	bite
	hurt	creek	rugged	snore	speed	furry	creepy
	injection	brook	sand	nap	quick	downy	animal
	syringe	fish	boards	peace	sluggish	kitten	ugly
	cloth	bridge	ground	yawn	wait	skin	feelers
Critical Items	sweet (.68)	thief (.83)	window (.69)				
Word Lists	sour	steal	door				
	candy	robber	glass				
	sugar	crook	pane				
	bitter	burglar	shade				
	good	money	ledge				
	taste	cop	sill				
	tooth	bad	house				
	nice	rob	open				
	honey	jail	curtain				
	chocolate	gun	frame				
	soda	villain	view				
	heart	crime	breeze				
	cake	bank	sash				
	tart	bandit	screen				

Number in parentheses next to critical item represent proportion of critical item recalls for that list

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