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ORIGINAL PAPER

A Brief Mindfulness Exercise Before Retrieval Reduces Recognition Memory False Alarms

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Abstract The impact of a 3-min state mindfulness exercise was investigated in recognition memory performance in order to test if memorial benefits would be found without long-term training. Four experiments (total $N=369$) compared the effect of the exercise before encoding versus retrieval. False alarms decreased after a 3-min mindfulness exercise prior to retrieval whether the stimuli were words (experiment 1) or nonwords (experiment 2). When the mindfulness exercise occurred before encoding, there was no benefit on error rates (experiments 3 and 4). The results suggest that even a brief state mindfulness exercise can have immediate and positive effects on recognition memory performance. Implications for improving practical memory tasks such as test taking or eyewitness memory are discussed.

Keywords Recognition memory · Mindfulness · Memory errors

Introduction

Everyday mindfulness exercises stem from short-term mindfulness meditation formats. For example, a series of experiments by Zeidan et al. (2010) examined the effects of mindfulness meditation training over a 4-day period on behavioral markers of cognition and mood. The mindfulness training produced a significant increase on cognitive tasks including verbal fluency and skills that required sustained attention or executive processing fluency. Zeidan et al. (2010) suggested that mindfulness training boosted cognitive performance by facilitating the ability to focus and regulate thoughts. Increased attention and organization are fundamental tenets for long-term recognition memory retrieval (Hicks and Marsh 2000). Similar benefits of mindfulness training on memory performance have been reported with long-term meditators (Baird et al. 2014). However, the results of Zeidan et al. give promise to the premise that shorter mindfulness exercises may also improve cognitive performance.

Another work that suggests mindfulness can improve cognitive performance was conducted by Levy et al. (2001). Although the focus of the work was on benefits in attention, memorial improvements from a mindfulness task were also reported. Specifically, participants in the mindfulness condition were encouraged to note distinctions in the encoded stimuli. Results indicated that participants in the mindfulness condition recalled significantly more pictures compared to participants who simply viewed the pictures. Levy et al. used a mindfulness exercise that was embedded in the encoding task as opposed to a separate experience. This is a different approach to mindfulness training compared to that of Zeidan et al. (2010), who focused on mindfulness exercises as separate from the learning component. Thus, at this time, the degree to which a separate, brief mindfulness task impacts memory is not well understood.

Finally, a recent paper by Bonamo et al. (2015) demonstrates that mindfulness exercises do have an impact on memory task performance. Bonamo et al. administered a mindfulness exercise of 20 or 45 min in length before participants learned novel Swahili-English word pairs. The performance

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of these groups on a cued recall test was better than that of a control group by about 10 %. The results of this study are promising for additional memory work for a number of reasons. First, they demonstrate that a single mindfulness experience is associated with changes in memory performance. Second, the researchers used a traditional memory paradigm. Third, the study leaves open a number of questions regarding the role of the mindfulness exercise: Will it also be effective if the task is recognition as opposed to recall? Will the exercise impact performance if it is placed before retrieval instead of encoding? Will an exercise less than 20 min also be effective?

Recognition memory refers to the ability to distinguish novel from previously experienced people, places, things, or (especially in the case of laboratory work) words. This type of memory underlies hundreds of decisions people generally make each day. It allows one to find a friend in a crowd, pick out an apple from the fruit bowl, turn into one's own driveway, and achieve any other task involving picking out the desired stimulus from distractors. It also has critical applied uses such as in eyewitness identification and in educational settings (Hammond et al. 2006). An eyewitness's task is to identify a suspect in a lineup (hit) while not identifying innocent people (false alarm). Similarly, in educational test performance, multiple choice exams require a test taker to distinguish the correct information from distractors. Because of the ubiquity of recognition memory tasks, understanding the role that mindfulness may play in hit rates and false alarms has the potential to yield important data for improving memory performance.

A person's recognition memory performance has been shown to be influenced by a myriad of factors, such as attention at study or test (Hicks and Marsh 2000), the frequency of the word (Glanzer and Adams 1990), or the type of stimulus to be remembered, with pictures usually better-remembered than words (Paivio 1973). A recent variable drawing interest for its impact on memory performance has been animacy. Nairne et al. (2013) and VanArsdall et al. (2013) have demonstrated that memory performance is superior for living (animate) as opposed to nonliving stimuli (inanimate). That is, a participant is more likely to recognize the word "dog" than "shoe" on a memory test even when factors relating to the words themselves (i.e., frequency, concreteness, etc.) have been controlled. This phenomenon has been referred to in the literature as the animacy effect. Interestingly, the animacy effect occurs even with nonwords made to be living or nonliving by the property associated with them. A participant is more likely to recognize the nonword "girv" on a later recognition memory test if it was presented at encoding with the property "has a four chambered heart" compared to the property "runs on batteries" (VanArsdall et al. 2013).

In the present study, we attempted to address three questions. (1) Can a brief (3-min) state mindfulness exercise improve memory performance? (2) Is a state mindfulness exercise equally beneficial to stimuli that represent living words compared to nonliving words? And (3) do observed benefits of mindfulness exercise depend on whether the exercise occurs before or after the presentation of to-be-remembered stimuli?

Experiment 1

Experiment 1 was conducted to test whether a brief mindfulness exercise would improve recognition memory performance for living and nonliving words. To our knowledge, this is the first study to explore the combined effects of brief meditation and animacy on recognition memory performance.

Method

Participants

Participants were taken from the Seton Hall University Psychology human research pool. Participants signed up for the study through a computer system and received course credit for participating in the study. A total of 81 students participated in this study. Although demographic data were not collected for this or the other experiments, the sample was mixed in terms of ethnic, gender, and SES makeup with the vast majority of participants aged 18–22.

Procedure

Participants completed the experiment individually. The study phase consisted of 100 words, with five primacy and recency buffers. Participants viewed the items one at a time. Each word was presented for 1 s. Participants were instructed to put on headphones in order to listen to an exercise. Participants were randomly assigned to the exercise conditions. In two of the exercise conditions, participants completed a 3-min mindfulness exercise (London 2013). One experimental group was told that the mindfulness exercise was meant to improve memory. The second experimental group was told that the mindfulness exercise reduced stress. The final condition was a control group where participants listened to 3 min of a neutral documentary regarding the history of radio. After listening to the exercise, participants completed a recognition memory test phase that included 24 words, half living and half nonliving (Nairne et al. 2013; VanArsdall et al. 2013). Half of the words were targets and half were lures. Participants were informed that the task was to say "yes" to items that were presented at encoding and "no" to those that were not presented at encoding. Each participant was tested individually. Each participant had a randomly ordered list of study and test items.

Measures

The experiment was conducted using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA). All word stimuli were obtained from Rubin and Friendly (1986). The words from the Rubin and Friendly (1986) study were used as untested stimuli, targets, and lures. Test words for the recognition test were categorized into living and nonliving words and taken from a study by Nairne et al. (2013) and were a subset of the material of Rubin and Friendly (1986). Living and nonliving are defined as a word's "animacy type." A 3-min breathing space mindfulness exercise was used in each experiment of this study. The exercise can be found at the following URL: http://www.uvm.edu/~CHWB/psych/audio/breathingspace.mp3. A 3-min clip from the full documentary on the history of radio was presented as a control listening exercise.

Data Analyses

The experiment was a 3 (exercise type: control, memory-improving mindfulness exercise, or stress-reducing mindfulness exercise) by 2 (test item type: targets or lures) by 2 (animacy type: living or nonliving words) mixed design. The exercise type was manipulated between participants. Test item type and animacy type were manipulated within participants.

Results

The dependent variable was the proportion of yes responses on the yes/no recognition test (see Table 1). An alpha of .05 was used for the main analysis and all follow-up tests reflect a Bonferroni correction. A 3 (exercise type: control, memory-improving mindfulness exercise, or stress-reducing mindfulness exercise) by 2 (test item type: targets or lures) by 2 (animacy type: living or nonliving words) mixed factor ANOVA was conducted. There was a main effect of test item type, $F(1,78)=337.75$, partial-$\eta^2=.812$. Participants said yes to more targets ($M=.70$) than lures ($M=.21$). There was a main effect of animacy type, $F(1,78)=16.87$, partial-$\eta^2=.178$. This result indicates that participants made more yes responses to living words ($M=.50$) than nonliving words ($M=42$). There was no main effect for the exercise type, $F(2,78)=2.03$, partial-$\eta^2=.05$, $p>.14$. There was no interaction between test item type and exercise type, $F<1$. There was no significant interaction between animacy and exercise, $F(2,78)=1.46$, $p>.24$, nor between test item type and animacy with $F(2,78)=1.03$, $p>.31$. Critically, there was a significant three-way interaction among test item type, animacy, and exercise, $F(2,78)=3.74$, partial-$\eta^2=.087$, and $p<.03$.

In order to interpret this important three-way interaction, four one-way between-factor ANOVAs for each type of test word (e.g., nonliving targets, living targets, nonliving lures, living lures) were conducted. Exercise type had an effect on nonliving lures, $F(2,78)=6.72$, $p=.002$. The effect was not significant in the other three test item types (e.g., nonliving targets, living targets, and living lures), all Fs <1. Post hoc tests on the nonliving lure responses revealed that both the memory improvement and stress reduction mindfulness exercise conditions had a lower false alarm rate than the control condition, $p<.01$. This indicated that the brief mindfulness exercise yielded a decrease in false alarms for nonliving lures.

Experiment 2

The number of stimuli in experiment 1 was relatively limited due to the matching of the words on a variety of variables. Thus, it is possible that the effect of a brief mindfulness exercise is limited. Further, the items had a level of preexperimental familiarity as they consisted of common words in the English language. Although item analyses suggested that the effect was consistent across all 12 nonliving words, it is still worthwhile to replicate the benefit of reduced false alarms after a brief mindfulness exercise using different stimuli. Nairne et al. (2013) have demonstrated that the animacy effect also occurs for items that are newly associated as living or nonliving. Specifically, the animacy effect was observed when participants studied nonwords that were given properties at encoding to suggest animacy properties (VanArsdall et al. 2013). Experiment 2 utilized these properties with a different set of nonwords to investigate whether the benefits of a brief mindfulness exercise on recognition memory performance would persist.

Method

Participants

One hundred and four participants from the same population of experiment 1, but who did not take part in experiment 1, were included in experiment 2.

Procedure

The procedure was similar to experiment 1 with the following exceptions. During the study phase, participants were presented with a nonword and a property that designated it as living (e.g., has a four-chambered heart) or nonliving (e.g., runs on batteries) (VanArsdall et al. 2013). The word appeared on the screen and the property was presented below it. The screen then changed after 1000 ms and was replaced with the text:

Table 1 Mean proportion of "yes" responses as a function of test item type, animacy, and meditation

Condition	Target		Lure	
	Living	Nonliving	Living	Nonliving
Experiment 1: exercise before retrieval				
Mindfulness (improve memory)	.72 (.04)	.62 (.04)	.23 (.04)	.12 (.03)
Mindfulness (reduce stress)	.75 (.04)	.67 (.04)	.27 (.04)	.14 (.03)
Control	.78 (.04)	.67 (.04)	.22 (.04)	.27 (.03)
Total	.75 (.04)	.65 (.04)	.24 (.04)	.18(.03)
Experiment 4: exercise before encoding				
Mindfulness (improve memory)	.78 (.04)	.72 (.04)	.18 (.04)	.21 (.03)
Mindfulness (reduce stress)	.83 (.04)	.69 (.04)	.17 (.04)	.14 (.03)
Control	.77 (.04)	.79 (.04)	.20 (.04)	.19 (.03)
Total	.79 (.04)	.73 (.04)	.18 (.04)	.18 (.03)

Standard errors are in parentheses

"Is _____ living or not?" Participants were instructed to press either the key labeled yes or no on the keyboard in response to this question. This additional instruction was included to ensure that participants were encoding the words in a way to suggest animacy or a lack of animacy. Participants were told before the study phase that memory for the nonwords would be tested.

After the presentation of 30 study items (15 nonwords paired with a living property and 15 nonwords presented with a nonliving property), participants completed a 30-s distractor task of pressing arrow keys. Participants then listened to either the same control or mindfulness exercise as in experiment 1. Because we found no effect of giving a purpose to the brief mindfulness exercise (i.e., reduces stress or improves memory), we eliminated this manipulation in experiment 2.

The recognition memory test consisted of 60 items: 15 nonwords studied with a living property, 15 nonwords studied with a nonliving property, and 30 lures that were not presented at study. Participants were instructed to use the yes and no keys to make their memory judgments, and the exact proportion of targets and lures were not divulged to participants. There were no properties presented during the test phase.

Again, participants were randomly assigned to either the brief mindfulness exercise or control condition. The order of the study and test lists was randomized by the computer for each participant. Nonwords were counterbalanced such that each one appeared as a target and lure and was paired with an animate or inanimate property approximately equally across participants. Due to an experimenter error when assigning to exercise condition, the final data set contained 51 participants in the control condition and 53 in the mindfulness condition.

Measures

Sixty pronounceable nonwords five to six letters in length (e.g., blerv) were generated using a nonword database (http://www.cogsci.mq.edu.au/~nwdb/nwdb.html). Properties for the nonwords suggesting that each was living (e.g., has a four-chambered heart) or nonliving (e.g., runs on batteries) were taken from VanArdsall et al. (2013).

Data Analyses

The study was a 2 (exercise type: control or mindfulness exercise) by 3 (test item type: living-labeled target, nonliving-labeled target, or lure) mixed factor design. Exercise was manipulated between participants and test item type was manipulated within participants.

Results

The results of experiment 2 are presented in Table 2. A significance level of .05 was used for all analyses with a Bonferroni correction for follow-up tests. A 2 (exercise type: control or mindfulness exercise) by 3 (test item type: living-labeled target, nonliving-labeled target, or lure) mixed factor ANOVA was conducted using the proportion of yes responses as the dependent variable. Critically, there was an interaction between exercise and test item type, F (2, 204) = 4.03, partial-η^2 = .04. The main effect of test item type (living-labeled target, nonliving-labeled target, or lure) was significant, F (2, 204) = 74.18, partial-η^2 = .42, such that participants elicited more yes responses to targets (M = .53 and M = .50 for living and nonliving nonwords, respectively) than to lures (M = .33). The main effect of exercise was not significant, $F < 1$.

The 2 (exercise type: control or mindfulness exercise) by 3 (test item type: living-labeled target, nonliving-labeled target, or lure) interaction was interpreted in two ways. First, we compared rates of yes responses

Table 2 Mean proportion of "yes" responses as a function of test item type, animacy, and condition for experiments 2 and 3

	Target		
Condition	Living	Nonliving	Lure
Experiment 2: exercise before retrieval			
Mindfulness	.51 (.03)	.52(.03)	.29 (.02)
Control	.55 (.03)	.48 (.03)	.35 (.02)
Total	.53 (.04)	.50 (.04)	.33 (.02)
Experiment 3: exercise before encoding			
Mindfulness	.59 (.02)	.56 (.02)	.35 (.02)
Control	.63 (.03)	.56 (.02)	.33 (.02)
Total	.61 (.03)	.56 (.02)	.34 (.02)

Standard errors are in parentheses

to each class of test item type as a function of exercise (control or mindfulness exercise). The difference was significant for lures such that participants in the mindfulness exercise group made fewer false alarms than participants in the control group, $t(102) = 2.2$. No significant differences were observed between the two classes of targets (i.e., living-labeled target and nonliving-labeled target) for participants in the brief mindfulness exercise group and the control group, $p < .24$. Second, we tested for a presence of an animacy effect in each group by comparing the hit rate to the living and nonliving targets. The animacy effect was significant for the control group, $t(50) = 2.6$, but not for the brief mindfulness exercise group, $p < .63$.

Experiment 3

Experiments 1 and 2 demonstrated that the benefits of a brief mindfulness exercise carry over from words to nonwords. These results suggest that memory performance can be improved with only a brief state mindfulness exercise. Experiment 3 investigated whether a brief mindfulness exercise would also be beneficial before encoding, as opposed to prior to retrieval.

Method

Participants

One hundred and twenty students from the same pool as experiments 1 and 2 participated in partial fulfillment of a course requirement. A power analysis suggested that 110 participants would be sufficient to detect an effect size comparable to experiment 2, but due to sign-up rates, more participants were included in the final sample size.

Procedure

Experiment 3 was identical to experiment 2 with one exception. Participants listened to either the control or brief mindfulness exercise prior to encoding instead of prior to retrieval of the 30 nonwords.

Measures

The materials used in experiment 3 were identical to the materials used in experiment 2.

Data Analyses

The study was a 2 (exercise type: control or mindfulness exercise) by 3 (test item type: living-labeled target, nonliving-labeled target, or lure) mixed factor design. Exercise was manipulated between participants and test item type was manipulated within participants.

Results

A significance level of .05 was used for all analyses with a Bonferroni correction to follow up tests. A 2 (exercise type: control or mindfulness exercise) by 3 (test item type: living target, nonliving target, or lure) mixed factor ANOVA was conducted using the proportion of yes responses as the dependent variable. There was a main effect of test item type, $F(2, 242) = 128.92$, partial-$\eta^2 = .52$. Neither the main effect of exercise type ($F < 1$) nor the interaction were significant, $F(2, 242) = 1.37$, $p < .27$.

To interpret the main effect of test item type, contrasts were conducted on the rates of yes responses for living targets ($M = .61$), nonliving targets ($M = .56$), and lures ($M = 34$). Results demonstrated that yes rates were highest for living targets followed by inanimate targets and then lures, $p < .01$. These findings demonstrate a significant animacy effect when a brief mindfulness exercise takes place before encoding in contrast to the elimination of the animacy effect when mindfulness exercise takes place before retrieval that was demonstrated in experiment 2.

Experiment 4

In experiment 4, participants again studied words that represented living and nonliving items. As in experiment 3, the encoding phase was preceded by either a 3-min mindfulness exercise or a control exercise. If mindfulness exercise effects on reduced false alarm rates depend on the temporal proximity between the mindfulness exercise and the presence of the test words, then it was expected that the results of experiment 4 would be the same as experiment 3 and false alarm rates would be equivalent in the control condition and in the mindfulness exercise condition. On the other hand, if part of the failure to see effects of mindfulness exercise at encoding on nonwords is due to the lower effect size of mindfulness exercise on performance for nonwords, the effect of reduced false alarm rates may also be observed for words even when the meditation occurs at a longer time before the lures are presented at test.

Method

Participants

Sixty-four participants from the same population as experiments 1–3 completed experiment 4 in partial fulfillment of a course requirement. The sample size was based on a power analysis of the results of experiment 1, which used the same stimuli.

Procedure

Experiment 4 was identical to experiment 1 except that the brief mindfulness exercise occurred before the list of words was studied as opposed to prior to retrieval. To facilitate comparison with experiment 1, we kept the conditions identical despite the type of mindfulness exercise (i.e., memory-improving mindfulness exercise or stress-reducing mindfulness exercise) having no effect in experiment 1.

Measures

The materials used in experiment 4 were identical to the materials used in experiment 1.

Data Analyses

The experiment was a 3 (exercise type: control, memory-improving mindfulness exercise, or stress-reducing mindfulness exercise) by 2 (test item type: targets or lures) by 2 (animacy type: living or nonliving words) mixed design. The exercise type was manipulated between participants. Test item type and animacy type were manipulated within participants.

Results

The average rate of yes responses as a function of exercise type, test item type, and animacy is presented in Table 1. A 2 (test item type: target or lure) by 2 (animacy: living or nonliving words) by 3 (exercise type: control, memory-improving mindfulness exercise, or stress-reducing mindfulness exercise) mixed factor ANOVA was conducted using the proportion of yes responses as the dependent variable. In contrast to experiment 1, only the main effect of test item type was significant with participants saying yes more often to targets than to lures, $F(1,61) = 329.69$, partial-$\eta^2 = .84$. In order to parallel the analyses of experiment 1, which demonstrated reduced false alarm rates to nonliving lure stimuli after the two meditation conditions, we ran the same planned contrasts using a Bonferroni correction. No effects were significant in these contrasts, all $p > .28$. Similarly, we tested for an animacy effect using planned contrasts with a Bonferroni correction. Only the exercise condition that was told that the mindfulness exercise would reduce stress showed an animacy effect for targets, $p < .01$.

Discussion

A 3-min brief mindfulness exercise is sufficient to change memory test performance when the exercise is given before encoding but not retrieval. Specifically, experiments 1 and 2 demonstrated that a brief mindfulness exercise before retrieval leads to a reduction in false alarms to lure items at test. Experiments 3 and 4 used a brief mindfulness exercise before encoding and demonstrated that the effect of reduced false alarms did not occur when the exercise occurred earlier in the experiment. These results are promising in several regards. First, memory errors are of concern in a number of applied settings including eyewitness memory and educational applications such as a multiple choice test. Second, the brief length of the mindfulness exercise is an advantage for both of these settings as it is not implausible to imagine giving students or witnesses a few minutes of a mindfulness exercise before testing occurs. Third, in experiment 1, the effects were limited to words that represent nonliving stimuli. This is consistent with theorizing that memory is biased toward that of living concepts (Nairne et al. 2013; VanArsdall et al. 2013). Thus, it may be more difficult to change memory performance on these types of nonliving items.

The overall finding that a brief mindfulness exercise is more impactful in improving memory when administered before retrieval than encoding makes sense if the effect is generally limited to false alarm rates. Because lure items only appear at test, having the benefit of a mindfulness exercise directly before the presentation of lure stimuli may have helped participants to distinguish these items more successfully. Further, this contrast also helps to explain the results of Bonamo et al. (2015) who found that a mindfulness exercise before encoding improved performance on a cued recall test, in which lures are not presented, relative to a control group. Recall and recognition memory rely on different test demands. In recall, one is given the context and asked to recall the item. In recognition tests, the item is given and the correct context must be discerned. Future research should investigate the types of memory errors that are most likely to be reduced after brief mindfulness exercises as a function of both timing of the exercise (i.e., prior to encoding or retrieval) and type of test (i.e., recall or recognition).

Although the impact of mindfulness exercise on reducing false alarm rates is relatively straightforward, the influence of mindfulness exercise on the recognition memory performance for living and nonliving items is less clear. For words, the animacy effect was present in experiment 1 when the mindfulness exercise occurred before retrieval. However, the animacy effect was observed only for the stress-reducing mindfulness exercise condition in experiment 4 when mindfulness exercise occurred before encoding. For nonwords, when the brief mindfulness exercise occurred before encoding (experiment 3), there was an overall animacy effect. In contrast, when the brief mindfulness exercise occurred before retrieval (experiment 2), the animacy effect was eliminated. Because the animacy effect is relatively new in memory research, further studies will likely help to delineate the factors that influence the nature of the animacy effect.

It is worth noting that the effect of the mindfulness exercise is small relative to that of the size of the difference between hit and false alarm rates. Such a finding is consistent with previous mindfulness memory research (Bonamo et al. 2015) and research in recognition memory generally. The greatest impact on memory decisions in a recognition memory test is whether the item is old or new. Other effects such as priming or context tend to be much smaller. However, in the context of the first experiment, the 15 % reduction in error rates is of practical benefit when translating these effects into the scale of classroom grades.

The results of these experiments are also complimentary to other research on the impact of a mindfulness exercise on memory performance. Heeren et al. (2009) found that mindfulness training can increase specific autobiographical memory retrieval while decreasing general autobiographical memory retrieval. This finding suggests that reducing overgeneralization may involve cognitive flexibility. Specifically, Heeren et al. demonstrated that mindfulness training had a significant positive effect on cognitive flexibility. Additionally, Mrazek et al. (2013) examined whether mindfulness training would improve cognitive performance on the Graduate Record Examination (GRE). The mindfulness training resulted in improved working memory capacity and reading comprehension scores. It was suggested that the enhanced performance was based on the ability of the mindfulness training to reduce distracting thoughts. If cognitive improvement as a result of mindfulness exercise can be shown on a daunting 4-h GRE, then it is plausible that the benefits of mindfulness exercise on cognitive performance may transfer to other test-taking contexts. Importantly, prior studies employed lengthy mindfulness training ranging from a 2-week mindfulness training (Mrazek et al. 2013) to an eight-session mindfulness-based cognitive therapy (MBCT) program (Heeren et al. 2009). Based on our examination of the literature, the findings of the present study are the first to show the benefits of a 3-min state mindfulness exercise on the reduction of false alarm rates. In essence, a 3-min mindfulness exercise is able to mirror some of the positive effects of longer mindfulness training by providing another way of studying state mindfulness (e.g., Bonamo et al. 2015).

Ideally, the present research would have benefited from a factorial design to manipulate the mindfulness exercise at encoding and at retrieval in the same study instead of across multiple experiments, as well as testing outside of a college student sample. However, due to participant pool limitations, the nature of the original project (honors thesis), and the surprising findings that occurred, the manipulation of encoding and retrieval occurred between studies. Future research could investigate the role of having a brief mindfulness exercise before both encoding and retrieval to assess whether the effects of mindfulness exercise on memory performance are additive. In addition, a measure of mindfulness such as the Toronto Mindfulness Scale (TMS) (Lau et al. 2006) should have been administered to investigate individual differences. Finally, in order to test the degree to which our results and other mindfulness effects are complementary, a direct comparison of state mindfulness and long-term training programs or expert practitioners should be the focus of future research.

The current study is also limited in that it does not specify the mechanism by which the mindfulness exercise has led to a reduction in errors. Because no research had yet investigated the role of brief mindfulness exercises in either recognition memory performance or the animacy effect, it was not reasonable to make strong theoretical predictions. Other research n mindfulness has demonstrated that meditation can reduce bias (Hafenbrack et al. 2014) and mind wandering (Morrison et al. 2014). Meditation has also been associated with reduced responding to rewarding stimuli (Teper and Inzlicht 2014). Some of these results may provide avenues for further research to specify the nature of the error reduction when mindfulness exercise occurs before a memory test. Again, administration of the TMS or another scale might also give insight for the nature of the effect. If error reductions are associated with higher scores on the overall scale or the various factors, this would suggest both mechanisms of the effect and future experiments of value.

The present results do suggest a few hints toward a likely mechanism for the times the brief mindfulness exercise benefitted memory performance. It seems probable that the mindfulness exercise is reducing the familiarity of lures. Specifically, in order to avoid endorsing a lure on a recognition memory test, one must avoid using other sources of familiarity in the memory decision. That is, related words are often falsely recognized more often than unrelated words. To avoid these errors, one must counteract that familiarity from semantic sources with evidence that there is not an episodic memory for the item using cues such as recency (e.g., "I haven't seen that word lately") or recollection rejection (e.g., "I remember studying DOG not CAT"). The mindfulness exercise before retrieval seems to function to make lure items less familiar in some way to participants. One potential relationship between memory performance and mindfulness may be on the second factor in the TMS, which relates to decentering. In a recognition memory test with known words, one must decide whether an item was presented on the recent list or not. Perhaps being able to take a broader view assists in these decisions because one is less likely to use irrelevant information for making the decision (e.g., a propensity to false alarm to "kitten" because of the memory of one's own pet).

Using an applied example, our results suggest that a brief mindfulness exercise in the context of eyewitness memory may decrease false accusations, but not improve recognition of actual perpetrators. This potentially aligns with the finding of Hammond et al. (2006) that a focused meditation enhanced correct responses during an eyewitness memory test, but focused meditation was not better than a context reinstatement procedure. Future research on face memory after a brief mindfulness exercise, particularly for in and out group members, would be an excellent next step in making the transition from word research to eyewitness memory studies.

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