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ORIGINAL PAPER

Meditation in the Higher-Education Classroom: Meditation Training Improves Student Knowledge Retention during Lectures

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Abstract The cognitive skills required for successful knowledge retention may be influenced by meditation training. The current studies examined the effects of meditation on the knowledge retention of students. In three experimental studies, participants from three introductory psychology courses randomly received either brief meditation training or rest, listened to a class lecture, then took a post-lecture quiz that assessed students' knowledge of the lecture material. The results indicated that meditation improved students' retention of the information conveyed during the lecture in each of the three experiments. Mood, relaxation, and class interest were not affected by the meditation training. Limitations and implications are discussed.

Keywords Learning · Meditation · Cognitive functioning · Higher education · Academic performance

Introduction

Mindfulness, the ability to maintain one's attention in the present moment, has long been theoretically associated with success in higher education. William James (1890) famously wrote that "the faculty of voluntarily bringing back a wandering attention, over and over again, is the very root of judgment, character, and will …An education which should improve this faculty would be the education par excellence (James 1890, p. 424)." However, when it came to giving advice about how to achieve mindful control over one's attention, even the father of psychology had to admit that it was "easier to define this idea than to give practical directions for bringing it about."

One hundred twenty years later, researchers are now making progress toward providing the kind of "practical directions" that James was seeking through meditation, a group of emotional and attentional regulatory strategies leading to the cultivation of well-being and emotional balance (Lutz et al. 2009). Generally speaking, meditation practices may be divided into two categories. The first category, open monitoring meditation, involves non-reactive monitoring of the moment-to-moment content of experience (Lutz et al. 2008). Open monitoring meditation is thought to facilitate nonreactive meta-cognitive monitoring and an awareness of automatic cognitive and emotional interpretations of sensory perceptive stimuli. The second category is focused attention meditation, which entails sustaining attention on a chosen thought or object. Focused attention meditation is thought to facilitate directing and sustaining attention on a selected object, detecting mind wandering, and reinstating directed attention (Lutz et al. 2008; Travis and Shear 2010).

A plethora of recent empirical data now suggests that meditation may enhance a variety of attention-dependent mental tasks. Researchers have demonstrated that focused and open-monitoring meditation increases performance on the Stroop task (Chan and Woollacott 2007), reduces the variability in attentional processing during dichotic listening tasks (Lutz et al. 2009), improves performance on the attentional blink task (van Leeuwen et al. 2009), and enhances performance on measures of the efficiency of attentional networks such as Fan et al.'s (2002) Attention Network Test (Tang et al. 2007). Extensive focused and open monitoring meditation is also associated with physical alterations to brain areas associated with the regulation of movements and learning. For example, research has shown that meditation may

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lead to increased cortical thickness (Lazar et al. 2005) and greater regional gray matter in the putamen cluster, a structure linked directly to attention deficit hyperactivity disorder (Pagnoni and Cekic 2007; Konrad et al. 2006). Researchers believe that these, and perhaps other, physical changes in meditators' brains facilitate long-term improvements in their self-regulation of sensory, cognitive, and emotional processing (Pagnoni and Cekic 2007).

In addition to meditation's positive effects on our attentional systems and resources, recent research has also documented other types of cognitive benefits associated with meditation. Kozhevnikov et al. (2009) have demonstrated that a form of focused attention Buddhist meditation called Deity Yoga improves visuospatial memory, and Ly and Spezio (2009) have found that open monitoring meditation improves decision-making. Moore and Malinowski (2009) found that open monitoring meditation enhances cognitive flexibility via performance on the Stroop task and the d2-concentration endurance test, a timed test of selective attention. Moore and Malinowski also demonstrated that self-reported levels of mindfulness were positively related to enhanced cognitive flexibility. Finally, researchers have demonstrated that meditation training may improve the central–executive functions Baddeley (2003) argues are necessary for students to solve problems creatively, including the vigilance necessary to attend to a long lecture (Kramarski and Mevarech 2003; Smit et al. 2004), and the judgment that students require to make important academic decisions (Butler and Winne 1995).

Until recently, most empirical studies on meditation relied on research designs that examined how meditation altered cognition over longer periods of time, that is, over the course of several weeks, months, or even years. Research of this type has demonstrated that meditation is a viable method for improving mood, levels of relaxation, cognition functioning, and self-regulation over the long-term (Basak et al. 2008; Grossman et al. 2004; Pagnoni and Cekic 2007). For example, Zylowska et al. (2007) have utilized meditation routines to treat children who had been diagnosed with attention deficit hyperactivity disorder, and Innes, Selfe, Brown, Rose, and Thompson-Heisterman (2012) have employed meditation routines to treat those suffering from Alzheimer's disease. While these studies have demonstrated practical long-term benefits for meditation, a smaller number of studies have also demonstrated potential cognitive benefits of meditation in the shorter term, either immediately following a meditation session or after only a small number of meditation sessions. For example, Srinivasan and Baijal (2007) demonstrated that focused attention mediators detect changes in the environment better following meditation, and Ramsburg and Youmans (2012) demonstrated that focused attention meditation may positively influence participants' decision-making and motivation while completing a complex problem-solving task.

Given that meditation benefits a wide variety of cognitive processes in both the short- and long-term, educators worldwide have begun to utilize meditation as a learning tool for students across a wide variety of age and education levels (Kirk et al. 2011; So and Orme-Johnson 2001; Zeidan et al. 2010). Fiebert and Mead (1981) examined whether focused meditation before studying and examinations would promote better knowledge retention compared with students meditating at different times. Baseline measures taken over the course of 3 weeks revealed no differences between groups, but meditation before examinations and study sessions resulted in better scores on examinations during the 9-week experimental period compared with participants that meditated at other times. Manger et al. (2002) designed a 9-month social–cognitive training program that included meditation-like training tasks that was able to improve the social–cognitive functioning of female schoolchildren. Beauchemin et al. (2008) provided students suffering from learning disabilities with a 5-week meditation course that included both focused attention and open monitoring styles of meditation. The program reduced student anxiety, increased social functioning, and improved academic achievement.

Unfortunately, because of the variability in the methods utilized among published studies on the academic benefits of meditation, many questions remain about what length, scope, and duration of meditation training is optimal to achieve positive academic results. For example, while research suggests that meditation may affect processes likely associated with knowledge retention and learning (Butler and Winne 1995; Zimmerman 1990, 2000; Zimmerman and Schunk 2001), variations in types of meditation that are employed by researchers can make it difficult to know which forms of meditation are optimal, or for how long a form of meditation would need to be practiced before students might expect to see benefits. Some researchers have also pointed out that relatively few studies have investigated the role that meditation might play in academic achievement using externally valid, experimental procedures necessary to establish causation between meditation and improved student learning (Meiklejohn et al. 2012; Napora 2011; Shapiro et al. 2011). In short, variations in how meditation has been studied and administered by researchers raises reasonable questions in the minds of skeptical educators regarding whether meditation would translate well into an educational setting.

Shapiro et al. (2011) echo these concerns in their comprehensive review of meditation in the context of higher education. Shapiro et al. call for rigorous empirical studies necessary to demonstrate how and to what degree meditation may enhance higher education. The present series of experiments were designed to test a series of hypotheses regarding the potential benefits of meditation training in higher-education classrooms. Experiment 1 tested the hypothesis that brief meditation training before a lecture would improve students' learning as measured by a short quiz following that lecture. Experiment 2 tested whether hypothetical improvements in student learning might occur due to increased student interest in lectures versus some other cognitive mechanism. Experiment 3 tested whether hypothetical improvements in student learning as a result of meditation would replicate on a different lecture topic that was presented in a different presentation format. Finally, because all three experiments utilized a novel method of administering meditation experimentally, the three experiments together represented a chance to test whether meditation could be experimentally administered before a higher-education classroom lecture without disrupting the learning environment.

Experiment 1

In Experiment 1, we administered a form of brief meditation training before an actual higher-education classroom lecture to test whether the meditation would improve students' performance on a short quiz about that lecture. Based upon prior research demonstrating that meditation may improve those cognitive functions necessary for learning (Butler and Winne 1995; Tang et al. 2007), we hypothesized that the students who meditated would learn more from the lecture than students who had not meditated. Because enhancements in mood and levels of relaxation have been reported following meditation training (Arias et al. 2006), we also measured students' self-reports of mood and level of relaxation.

Method

Participants

Participants in this study were 35 undergraduate psychology students who were enrolled in an Introduction to Psychology course at a California state university. Access to the student population was gained by consent from the course instructor. Of the 35 participants, 27 were males, 8 were females, and the mean age was 18.09 years. Participants identified themselves as Caucasian (26.10 %), Asian or Pacific Islander (4.30 %), more than one race/other (2.20 %), Black/African-American (4.30 %), Middle Eastern (6.50 %), Latino/Hispanic (32.60 %), and declined to state (23.90 %). Thirty-three students were freshman, one was a sophomore, and one was a senior.

Meditation Style

Although there are many different types of meditation (e.g., Vipassana, Zen, Transcendental, Yogic, Mantra, Jain, and many others), participants in this experiment were given the first type of meditation taught to novices within the Zen Buddhist meditation tradition for over eight centuries, the counting method. In this method, the practitioner sits with a straight back and counts his or her own breaths, usually from 'one' to 'ten' and back to 'one,' repetitively. If at any time the practitioner loses count, he or she is instructed to return to 'one' and continue the breath-counting cycle. The main purpose of this form of meditation training is to improve the practitioner's joriki, which is a special type of concentration thought to develop as people practice meditation (Kapleau 1980). The counting supports the focus on meditators' breath, which helps to diminish wandering thoughts. The counting method and other focused attention forms of meditation have been used extensively in past research in conjunction with open monitoring meditation (for a review, see Lutz et al. 2008; see also Ramsburg and Youmans 2012; Tang et al. 2007). The present study offered the opportunity to study exclusively whether focused attention meditation may produce measurable gains in knowledge retention. The counting method of meditation was chosen by one of the researchers who at the time of the study had a meditation experience of more than 10 years, which included teaching meditation to novices at various meditation centers.

Materials and Measurement

Demographic Data A brief demographic questionnaire was used to assess age, sex, year in college, and major field of study.

Brief Mood Introspection Scale (BMIS) The BMIS was used to examine mood effects (Mayer and Gaschke 1988). The BMIS is a scale where participants rate how they feel on a four-point Likert scale from "definitely do not feel" to "definitely feel" for 14 mood adjectives. The scale is empirically grounded and well anchored allowing for internal and external validity (see Mayer and Gaschke 1988).

Positive Affect Negative Affect Scale (PANAS) The PANAS was used to examine mood effects (Watson et al. 1988). The PANAS is a scale consisting of words that describe different feelings and emotions. Participants indicate to what extent they are experiencing the adjectives on a five-point Likert scale from 'Not at All' to 'Extremely' for 20 mood adjectives. The scale is empirically grounded and well anchored allowing offering internal and external validity (Watson et al. 1988).

Behavioral Relaxation Scale (BRS) This scale was to assess the participants' current level of relaxation (Poppen 1988). Participants needed to choose from one of the following seven options: (1) I feel more deeply and completely relaxed than I ever have. (2) I feel completely relaxed throughout my entire body. (3) I feel more relaxed than usual. (4) I feel relaxed as in my normal resting state. (5) I feel some tension in some parts of my body. (6) I feel generally tense throughout my body. (7) I feel extremely tense and upset throughout my body. The scale is empirically grounded and well anchored allowing internal and external validity (Norton et al. 1997).

Quiz A quiz was designed to test knowledge retained from the lecture. The quiz contained seven total questions, three multiple-choice questions, and four fill-in-the-blank questions. The quiz was developed with the instructor based on the content from the lecture that was to be given that same day. Students were made aware at the beginning of the lecture that a quiz would be administered at the conclusion of the lecture. An example of one of the multiple-choice quiz questions is: "Which of the following will most likely lead to stress? A. exercise, B. apathy, C. negative emotion, D. reciprocity." An example of one of the fill-in-the-blank quiz questions is: "Being able to adapt to stressful situations is called ____________?"

Design and Procedure

Experiment 1 utilized a between-participants experimental design. Participants were greeted at the start of an otherwise normal Introduction to Psychology course and asked to participate in a short activity that would be related to that day's lecture on health and psychology. Participants received informed consent forms and were then randomly provided with one of two versions of a paper packet with writing on it that had been folded over and stapled. The randomization process consisted of randomizing the information packets and then handing them out to students. From the students' perspective, both versions of the packets were identical. The BMIS mood questionnaire was printed on front of the packet, and participants began the experiment by answering those brief questions about their mood.

Next, participants were instructed to flip the packet over and follow the directions printed on the back of the packet. One version of the packet, the meditation version, contained directions for what was described as a self-test of focused relaxation, with simple instructions for attempting the counting method of meditation training. The students were asked to close their eyes, remain silent, and attend to their breathing. The second, non-meditative version of the packet contained directions for resting, where participants were asked to close their eyes and rest for 6 min. Rest is commonly used as a comparison activity in meditation studies (e.g., Cahn and Polich 2006; Kozhevnikov et al. 2009). However, there are cognitive benefits associated with resting. Therefore, while our hypothesis was that the meditation condition would outperform the rest condition, it may be more appropriate to consider the rest condition as a comparison group. Because participants were all quietly seated next to one another with their eyes closed, there was no reason for the students to suspect that they were not all performing the same mental task (i.e., either meditating or resting), which was important for isolating the effects of the cognitive training from other nuisance variables. From the students' perspective, they were all participating in the same class exercise, but in reality half of the class was meditating and half were not.

After 6 min had passed, the experimenter asked the participants to stop, open their stapled packets, and fill out the enclosed questionnaire containing additional mood (BMIS) and relaxation questions (the BRS; Poppen 1988). The experimenter collected the forms, thanked the participants, and left the class. The entire procedure took approximately 15 min. The students then proceeded with the normal 50-min lecture on the topic of health and psychology from their regular instructor. The instructor announced to the students that a quiz would be administered at the end of class on the material being presented, and as indicated, students took that quiz at the conclusion of the lecture. After students turned in their quizzes, they completed a short demographics questionnaire, and finally the students were debriefed.

Results and Discussion

Random distribution of the paper instruction packets yielded 18 students who meditated and 17 that rested. Our analysis of Experiment 1 focused on participants' self-report ratings and quiz performance. Specifically, we examined which condition led to better quiz performance and whether mood and behavioral relaxation were affected by the meditation. Prior to the meditation or rest manipulation, mood surveys detected no differences in the student's moods with respect to positive or negative affect via an analysis of variance (ANOVA), $F(2, 31)=0.50$, $p=0.613$, nor did moods differ following the training, $F(2, 32)=0.48$, $p=0.621$ (see Table 1). While some studies have shown that mood is affected by meditation in the long-term, we had not expected strong changes in mood as a result of meditation given the brevity of the meditation utilized here. However, those students who had been randomly assigned to the meditation condition reported higher levels of behavioral relaxation following the meditation training, $t(33)=2.84$, $p=0.008$.

Finally, our results indicated that students who were randomly assigned to the meditation condition performed better on the post-lecture quiz than students in the rest condition using a two-tailed *t* test, $t(33)=1.84$, $p=0.043$; $d=0.64$. Correct answers on the quiz ranged from three to seven, and the effect size for quiz performance was found to be a medium effect according to Cohen's (1988) convention for a medium effect (see Table 1 for Ms and SDs). Due to the relatively small sample size, more

Table 1 The means and standard deviations for mood, relaxation, and quiz performance

		Mood					
		Pre		Post			
		PA (PANAS)	NA (PANAS)	PA (BMIS)	NA (BMIS)	Relaxation	Quiz score
Meditation	M	26.24	15.41	21.00	16.06	4.72*	6.33*
	SD	6.46	4.61	4.07	4.45	1.18	0.69
	M	23.76	16.53	19.35	16.12	3.65*	5.70*
Rest	SD	9.50	6.63	6.50	4.86	1.06	1.05

PANAS scores were summed scores for ten NA and ten PA measures each scaled from 1 (very slightly or not at all) to 5 (extremely). BMIS were also summed score, eight NA and eight PA measures each scaled from 1 (definitely do not feel) to 4 (definitely feel). Relaxation scores were measured from 1 (I felt extremely tense and upset throughout my body) to 7 (I felt more deeply and completely relaxed than I ever have)

PA positive affect, *NA* negative affect, *PANAS* positive affect negative affect scale, *BMIS* brief mood introspection scale

*$p<0.05$

complex analyses were not conducted as they might have resulted in type 2 error. Nonetheless, in the interest of fully describing the data, we have included an analysis of covariance (ANCOVA), which found that behavioral relaxation did not influence scores on the quiz, $F(1, 32)=0.13$, $p=0.717$.

Experiment 1 demonstrated the feasibility of utilizing the counting method of meditation training in an ordinary higher-education classroom. One qualitative measure of the success was that the instructor who had allowed us to conduct the study in her classroom reported that she thought that the meditation had created a better learning environment and volunteered that she would be happy to use her class again if we conducted any future studies of meditation. Data analysis subsequently revealed that students who had meditated performed better on a post-lecture quiz, suggesting that meditation training may be an effective method for improving academic performance.

However, after only one experiment, very little could be said about why meditators' quiz scores had improved. Following Experiment 1, we concluded that something about the meditation had improved quiz performance, but what was the mechanism underlying the improvement? Because the improvements in meditators' quiz scores did not appear to be mediated by mood or relaxation effects, we wondered at the conclusion of Experiment 1 whether the improved quiz scores might have arisen from increased *interest* on the part of the students who had completed the meditation on the topic of that day's lecture, which was about health and psychology. The meditation could have increased students' interest in the lecture topic itself, which might explain their improved quiz performance.

Experiment 2

Experiment 2 was designed to test the hypothesis that meditators' quiz scores had improved in Experiment 1 as a result of their increased interest in the lecture topic. We also conducted Experiment 2 in order to replicate the techniques and primary findings of Experiment 1 to protect against a possible Type 1 error (i.e., that we had found improved quiz scores in the meditation condition due to coincidence). Therefore, Experiment 2 was identical to Experiment 1 in design, except that we asked the participants at the end of the class lecture to rate how interesting they thought the class lecture had been that day. We hypothesized that a replicated increase in quiz performance that was accompanied by an increase in students' levels of interest would provide evidence that student interest in the lecture topic was the mechanism responsible for their improved quiz performance.

Method

Participants

Participants in this study were 55 undergraduate psychology students and one graduate student enrolled in an Introduction to Psychology course at a California state university. Experiment 2 took place in the academic semester following Experiment 1, and access to the student population was gained by consent from the same course instructor who had volunteered to participate in Experiment 1 previously. None of the students in Experiment 2 had participated in Experiment 1. Of the 56 participants, 23 were males, 32 were females, and the mean age was 18.52 years (one participant did not fill out the demographics form). Participants identified themselves as Caucasian (22.80 %), Asian or Pacific Islander (8.80 %), Asian Indian (1.80 %), Black/African-American (24.60 %), Middle Eastern (3.50 %), and Latino/Hispanic (35.10 %), Native American (1.80 %), and declined to state (1.80 %). Forty-five students were freshmen, eight were sophomores, two were juniors, and one was a graduate student.

Design and Procedure

The same procedure as in Experiment 1 was used in Experiment 2. Students listened to the same class lecture on Health and Psychology as the students had in the previous semester during Experiment 1, and the same instructor gave the lecture. The quiz that was administered following the lecture was also the same as the quiz that was used in Experiment 1, with the addition of one question at the end asking "how interesting was the class lecture for the day" on a five-point Likert scale (1=Not at all interesting, 5=Very interesting).

Results and Discussion

Random distribution of the paper instruction packets yielded 30 students who meditated and 26 that rested. Our analysis of Experiment 2 indicated that those in the meditation condition did not significantly differ in pre-meditation mood, $F(2, 52)=1.10$, $p=0.339$, and there were no differences between conditions on post-meditation mood, $t(53)=1.26$, $p=0.214$. Additionally, no statistical differences were found for behavioral relaxation, $t(55)=0.04$, $p=0.901$. Importantly, we detected no difference between either conditions' interest in the class lecture, $t(53)=0.32$, $p=0.749$. Admittedly, as with any self-reported measure, there is a possibility of biases from students when asked to rate the class.

However, just as we had found in Experiment 1, students who had been randomly assigned to the meditation condition performed better on the quiz following the lecture than those students randomly assigned to the rest condition as indicated using a directional *t*test, $t(54)=2.12$, $p=0.038$; $d=0.58$. Correct answers on the quiz ranged from two to seven. The effect size for quiz performance was found to be a medium effect, replicating the main finding from Experiment 1 (see Table 2 for Ms and SDs). Additionally, an ANCOVA revealed that post mood, $F(1, 48)=1.01$, $p=0.320$, relaxation, $F(1, 48)=0.01$, $p=0.755$, and class interest, $F(1, 48)=0.48$, $p=0.490$, did not influence quiz performance, which was improved with meditation training, $F(1, 48)=4.81$, $p=0.033$. The results of Experiment 2 indicated that meditating prior to a classroom lecture improved students' quiz performance, regardless of their level of interest for the class lecture, and irrespective of their mood and relaxation level.

Experiment 3

At the conclusion of Experiment 2, we were much more confident that meditation had improved students' knowledge retention of the lecture. The meditation training had been randomly assigned to students who were unaware of the manipulation, and the quiz score benefits that the meditating students had received had been replicated. Additionally, quiz scores were shown to be independent of students' self-reported interest in the class. However, after two experiments, we still did not know why meditators' quiz scores had improved. Improvements in meditators' quiz scores did not appear to be mediated by mood or relaxation effects, or by increases in interest in the topic of that day's lecture. Therefore, we wondered whether the effects of meditation training on quiz performance might be due to the close association between meditation and the lecture topic itself, i.e., health and psychology. Therefore, we conducted Experiment 3 in order to determine whether the key findings of Experiments 1 and 2 would replicate on a different lecture topic and presentation format.

To do so, we identified an Introduction to Psychology course where students were scheduled to watch a video recording of a lecture by Philip Zimbardo, a well-known psychologist in the United States, on the topic of Testing and Intelligence from the Discovering Psychology video series. The particular lecture was chosen because we could think of no strong overlap between the presentation topic and the topics of meditation or applied cognitive training. Additionally, Experiment 3 also provided a means to test whether the learning improvements that meditation had brought about in Experiments 1 and 2 would replicate when students were watching a recording of a lecture, a lecture format that is becoming more common as universities adopt so-called online or distance higher-education programs.

Method

Participants

Participants in this study were 93 undergraduate psychology students and one graduate student enrolled in an Introduction to Psychology course at a California state university. Access to the student population was gained by consent from the course instructor. None of the students in Experiment 3 had participated in Experiments 1 or 2. Of the 94 participants, 30 were males, 62 were females, and the mean age was 19.03 years (two participants chose not to fill out a demographics form so their data are excluded). Participants identified themselves as Caucasian (19.40 %), Asian or Pacific Islander (12.90 %), more than one race (3.20 %), Asian Indian (1.10 %), Black/African-American (15.10 %), Middle Eastern (8.60 %), Latino/Hispanic (37.60 %), and declined to state (2.20 %). Forty-seven participants were freshmen, thirty-three were sophomores, nine were juniors, two were seniors, one was a graduate student, and one participant did not indicate class standing.

Table 2 The means and standard deviations for mood, relaxation, quiz performance, and class interest

		Mood					
		Pre		Post			
		PA (PANAS)	NA (PANAS)	SA (BMIS)	Relaxation	Quiz score	Class interest
Meditation	M	27.00	14.77	45.50	4.30	5.73*	4.24
	SD	8.45	3.82	5.91	1.06	1.17	0.74
	M	30.36	15.48	47.60	4.24	4.92*	4.31
Rest	SD	8.74	5.72	6.46	1.27	1.67	0.79

Summed affect scores were computed by adding positive affect scores to reverse scores of negative affect. Quiz scores were a maximum of seven points

PA positive affect, *NA* negative affect, *SA* summed affect, *PANAS* positive affect negative affect scale, *BMIS* brief mood introspection scale

*$p<0.05$

Quiz

The quiz used in Experiment 3 was different from that which had been administered in Experiments 1 and 2 because the topic of the video lecture was different. There were seven total questions, four multiple-choice questions, two short-answer questions, and one true-or-false question. An example of one of the multiple-choice questions used is: "Who developed the first well-known test of intelligence? A. Claude Steele, B. Stanford Binet, C. Lewis Truman, or D. Alfred Binet." An example of one of the short answer questions used is: "What is stereotype threat?"

Design and Procedure

With the exception of the video presentation, the same general procedure was utilized in Experiment 3 as was used in Experiments 1 and 2. A small change was made to the type of mood survey that was being used. We utilized only the PANAS for pre- and post-mood measures because it offered six additional mood adjectives not offered in the BMIS, but otherwise participants completed the identical manipulation used in the previous experiments, and then watched the 35-min video lecture.

Results and Discussion

Random distribution of the paper instruction packets yielded 46 students who meditated and 48 that rested. Our analysis of Experiment 3 indicated that those in the meditation condition did not significantly differ in pre-mood, $F(2, 88)=0.27$, $p=0.762$, nor post-mood, $F(2, 88)=0.78$, $p=0.356$. Likewise, behavioral relaxation, $t(91)=0.001$, $p=0.888$, and class interest, $t(80)=0.80$, $p=0.424$ were unaffected by meditation. Correct answers on the quiz ranged from one half to seven, and the meditation condition again performed better on the quiz than the rest condition evidenced by a one-tailed *t*test, $t(92)=1.80$, $p=0.038$; $d=0.38$, replicating Experiments 1 and 2. The effect size for quiz performance was found to be a small to medium effect according to Cohen's (1988) convention for a small effect (see Table 3 for Ms and SDs).

Experiment 3 demonstrated that meditation training before a video lecture on a topic unrelated to meditation improved performance on a quiz about the lecture. Although both the presentation style (i.e., a recorded lecture) and the lecture topic (i.e., testing and intelligence) did lower the baseline student quiz performance, the topic and lecture format did not influence the relative improvement in performance that meditating students demonstrated.

However, after three experiments, the authors admit that we do not fully understand the underlying mechanisms by which meditation was able to improve knowledge retention of the students in each of these three studies. After ruling out mood, relaxation, interest, and interactions with the style or content of the lecture, we now speculate that the salutary benefits we detected may have been due to increases in the meditating students' self-regulatory functioning, specifically their ability to delay gratification or avoid impulsive behaviors (see Muraven and Baumeister 2000; Muraven et al. 2006; Schmeichel et al. 2003). We also know that students who are less able to self-regulate are less likely to perform well in school (Butler and Winne 1995; Zimmerman 2000; Zimmerman et al. 1992) and that the ability to self-regulate may be diminished during long tasks that require consistent self-regulation like attending to a course lecture (Muraven and Baumeister 2000; Muraven et al. 1998; Vohs et al. 2008). Given that self-regulation is a mental resource that is susceptible to depletion (Muraven and Baumeister 2000), we now believe that a plausible explanation for the improvements we detected in meditating students' knowledge retention could be that the meditation somehow *boosted* students' ability to self-regulate in the short-term, allowing students who meditated to concentrate longer on the lecture material.

Table 3 The means and standard deviations for mood, relaxation, quiz performance, and class interest

		Mood						
		Pre		Post				
		PA (PANAS)	NA (PANAS)	PA (PANAS)	NA (PANAS)	Relaxation	Quiz score	Class interest
Meditation	M	28.06	15.46	23.33	13.09	3.89	3.90*	2.73
	SD	7.60	5.99	10.90	5.51	1.17	1.57	1.00
	M	28.06	16.38	26.36	13.34	3.89	3.33*	2.93
Rest	SD	8.42	6.57	9.15	3.81	0.67	1.50	1.19

Quiz scores were a maximum of seven points

PA positive affect, *NA* negative affect, *PANAS* positive affect negative affect scale

*$p<0.05$

Unfortunately, Experiments 1–3 utilized no direct measures self-regulation, a fact that makes testing the boost hypothesis difficult. However, because we had collected demographic information, we were able to perform one additional analysis on our data to indirectly test whether the meditation we administered might have been of greater benefit to students with low self-regulatory functioning. To do so, we reasoned that students who are better able to self-regulate are more likely to perform well in school (Butler and Winne 1995; Zimmerman 2000; Zimmerman et al. 1992) and therefore, that students with higher self-regulatory functioning in higher education were more likely to continue their education (see Flowers 2002; Kitsantas et al. 2008; Nota et al. 2004). As a consequence, we reasoned that the number of students with low self-regulation would be greatest among freshman, and we tested whether the meditation training we had provided had produced a greater benefit to freshmen by comparing the percentage of freshman in each of our samples to the effect size of the meditation on quiz performance. Table 4 demonstrates the observation that, as the percentage of freshmen in the three classes we studied declined, so too did the effect size of the meditation training we provided. While this analysis was conducted post hoc, the data are consistent with the idea that the students who were most likely to be low in self-regulatory functioning (i.e., the freshmen) also received the greatest benefits to their knowledge retention as a result of the brief meditation session.

General Discussion

A series of three experiments were conducted in three different higher-education classrooms to test whether a brief form of meditation that was administered on paper prior to a college lecture would improve the knowledge retention of students. The results of the three experiments repeatedly demonstrated that students who meditated before a lecture performed better on a post-lecture assessment than students who rested. These experiments also showed that the improvements in students' knowledge retention were not due to changes in the meditating students' mood, their levels of relaxation, conscious increases in students' interest in the lecture, or because of some unconscious priming between meditation and the lecture topic. Based on our results, we now believe that it is reasonable to conclude that brief periods of meditation via the Zen counting method are an effective method of improving students' retention of information in introductory college courses.

One contribution of the present study is that we have examined meditation and knowledge retention using an experimental method that Shapiro et al. (2011) and others have argued is necessary to establish causal links between meditation and salutary effects. Random assignment does not always result in the ability to infer causation, but because the students in our experiments were randomly assigned to either a meditation or control conditions, the two groups were likely to be statistically equivalent in every other way but the meditation manipulation (see Youmans 2012). The chance that the effects were caused by some other variable are further reduced by virtue of the replication of the effect across three different experiments. As such, we have provided strong evidence for causality between the meditation manipulation and the increases we detected in quiz performance, and we view our results as yet further evidence for the salutary benefits of meditation that have already been documented via nonexperimental methods (e.g., Cahn and Polich 2006; Chan and Woollacott 2007; van Leeuwen et al. 2009).

Table 4 Are the effects of cognitive training mediated by individual differences in the ability to self-regulate?

Experiment #	Percentage of freshmen enrolled	Cohen's D
1	94.29 %	0.64
2	80.36 %	0.58
3	50.54 %	0.38

Other contributions of our study stem from the brevity of our meditation manipulation that was sufficient to produce measurable gains in knowledge retention after only one session lasting 6 min. Creating a brief meditation condition was important because one of our goals had been to find some method of meditation that could be realistically administered before a higher-education classroom lecture without disrupting the learning environment. In our case, not only did the meditation lead to better knowledge retention, but the instructors who volunteered their classes for testing both anecdotally agreed that the meditation had been easy to administer and even had seemed to have a calming effect on their class. While we view these outcomes as modest reasons for instructors who are interested in incorporating meditation to consider using our methods, we note that researchers have also demonstrated the effectiveness of computer-based cognitive intervention programs (e.g., Basak et al. 2008; Manger et al. 2002; Smith et al. 2009; Willis et al. 2006). Theoretically, these types of manipulations might show the same, or greater, knowledge retention effects, and may be easier for instructors to administer in classes where computers are present or during online instruction. Finally, we note that the majority of participants in our study were Latino. To the authors' knowledge, there is no research that directly examines the effects of meditation on a Latino population's knowledge retention. The present findings therefore support the use of meditation as a potential means to help minority student populations with knowledge retention.

All studies have limitations, and here, many were the result of tradeoffs between the control afforded by a laboratory study and the ecological validity of a study that collects data in the actual setting of interest. By conducting our research in a real higher-education classroom with students who were attending an actual class lecture for course credit, we were forced to make many concessions that future laboratory studies may wish to address. One example was our utilization of a quiz that needed to be fair to the students and cover the lecture material, which prevented us from using a more established measure of learning. Additionally, the time differences between training and test differed because of differences between the durations of time that the classes met, from 50 min for Experiments 1 and 2, to only 35 min for Experiment 3. These differences might have produced some unintended temporal effects. We also could not employ any direct measures of self-regulation or attentional processing given the classroom setting. A third example was that no manipulation check on student engagement was conducted due to requests to keep our manipulation as short as possible and also because we worried about how we would maintain the illusion that the experimental and control conditions were completing the same task. But with no measure of how engaged the meditators were in the meditation task, one cannot predict how our effect might hold across other settings and populations where levels of engagement might be different. These realities qualify what readers should conclude about the degree to which using the Zen counting method may affect student learning. On the one hand, the effects of meditation might be the same, or even higher, if engagement in the meditation is strong. However, the effects of meditation on classroom learning might quickly diminish if engagement wanes, for example, as the novelty of engaging in meditation for the first time diminishes. Future researchers with interests in applying meditation in academic settings are encouraged to address these issues using established measures of learning and engagement.

Finally, an additional limitation of the studies reported here was our failure to uncover more evidence about what underlying mechanisms might be mediating the effects of meditation on knowledge retention. We found no evidence that the effect was due to changes in students' mood, relaxation, or interest with the material and only limited post hoc evidence for mediation via self-regulation. Previous research has demonstrated that meditation is a viable method for improving mood, levels of relaxation, cognition functioning, and self-regulation over the long-term (Basak et al. 2008; Grossman et al. 2004; Pagnoni and Cekic 2007), leaving the cause of our findings rather mysterious, and threatening the internal validity of the study. The authors are left to speculate that self-regulation is a cognitively demanding task that can be aided by meditation creating additional cognitive capacity useful for learning. This post hoc speculation was supported by differences in the effect sizes of the meditation on the basis of the ratio of first year to more senior students in the class (see Table 4), but these proportions were also confounded with materials and test procedures, making it difficult to draw any definitive conclusions about the effect of year in college. On the basis of these and other findings implicating self-regulation with learning enhancements, we encourage future researchers to directly measure self-regulation as a mediator between meditation and learning enhancement.

James (1890) believed that an education could improve attentional faculties would be the education "par excellence" (p. 424), but we humbly recommend that educators who may be considering whether to adopt meditation in the classroom do so only after weighing the potential pros and cons. While the enhancements in quiz performance in the introductory courses we tested were reliable, we note that they were also somewhat modest. Meditation increased quiz scores between only 7–8 % above those students who rested, and we did not test whether the effects would persist, for example, if meditation were used in the classroom often or if instruction was given verbally in a guided meditation. It is possible that there could be differences in meditation presented either textually or verbally and that verbal guided meditation in the classroom might improve engagement in the practice. We were also unable to test whether meditation would improve knowledge retention in situations where there were delays between lectures and evaluations. For example, we do not know whether meditation would affect students' performance on a cumulative final exam. Of course, educators should also consider that the present study was able to demonstrate measurable change in student performance with only 6 min of meditation training, with other research demonstrating that the positive effects may last months (Fiebert and Mead 1981) and may persist even after training is discontinued (Basak et al. 2008). Introducing meditation in the classroom also produces other student benefits beyond grade increases, including greater student interest in topics related to meditation, mindfulness, and self-regulation and greater understanding and appreciation of the differences between eastern and western psychology (Hull 2001; Michaelson 2006). Providing different points of view about lecture topics has also been shown to improve students' problem solving (Griggs 2003) and creativity (Leung et al. 2008). Finally, numerous studies have shown enhancements in cognitive, physiological, and neurological functioning with meditation training (Brown et al. 2007; Cahn and Polich 2006); these improvements are likely to be of benefit, and of interest, to a variety of student populations.

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