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Asher Evan Siegelman April 15, 2011

Mindfulness and Test Performance

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Abstract

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Most college students report experiencing test anxiety at some point in their education; 15-20% report levels that interfere with performance. Mindfulness meditation coupled with relaxation has been shown to reduce stress and anxiety, but little has been done to determine the impact of mindfulness techniques on test performance. Mindfulness is enhanced attention and awareness to the present moment. This study was conducted to both determine the impact of mindfulness on test performance and whether mindfulness is a cognitive skill or a cognitive skill coupled with relaxation. Fifty-six undergraduates were randomly assigned to mindfulness meditation training, cognitive skills training, or music relaxation. After a week of 20 minute daily mindfulness meditation, cognitive skills acquisition or listening to relaxing music, the participants were exposed to a mild stressor and then tested with a spatial reasoning task. They then took course examinations on their regular schedule. There were no significant group differences in performance on the spatial reasoning task, but all groups performed at an advanced level. Classroom performance was not significantly different between groups. The hypotheses of this study were not supported. Planned contrasts revealed that the music control functioned as a third type of cognitive training due to high levels of self-reported focus. Future research would need to utilize a relaxation technique that functions as an active control.

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Introduction

Test performance is a major component of academic life that determines not only grades, but also college and graduate school admissions. Most college students report experiencing test anxiety at some point in their education; 15-20% report levels that interfere with performance (Zeidner, 1998). Arkin and Detchon (1982) found that college students who have high levels of test anxiety view themselves as having a low chance of success and even if they experience success, they do not attribute it to ability or effort. These authors explain that test anxiety negatively affects a student's motivation, attention, and informational processing leading to poorer performance.

Two approaches have been taken to improve performance. Educators and researchers have worked to develop methods for reducing test anxiety and as part of that effort have created general techniques for enhancing test performance. These methods range from test taking strategies to relaxation techniques to mindfulness techniques. Mindfulness is attention and awareness to the present moment. A small number of studies have utilized mindfulness techniques in a second approach to improving performance by focusing solely on performance enhancement. These studies lead to significant improvements, begging the question, "How do these techniques work to enhance test performance?" Shapiro, Carlson, Astin and Freedman (2006) conceptualized mindfulness as made up of three components - intention, attention and awareness. What seems to be a common theme throughout the studies on test anxiety and test performance is a focus on enhancing attention, intention and attitude toward the test experience. However, along with a focus on enhancing these cognitive components is often a focus on increasing relaxation. If the cognitive components of mindfulness are what improve test

performance then combining relaxation with mindfulness is not necessary. The purpose of this study is to determine if mindfulness training will improve test performance and if this improvement is due to cognitive skills or a combination of cognitive skills and relaxation.

Research on Test Anxiety

Early research on test anxiety emphasized cognitive processes such as worry. Doris and Sarason (1955; as cited by Sarason, 1984) found that people with high test anxiety tended to have more self-blame concerning performance and Trapp and Kausler (1958) found that those with high test anxiety set lower standards for themselves. In 1967, Leibert and Morris argued that the components of test anxiety could be either cognitive or emotional. They surveyed 54 undergraduates immediately before a major exam to determine how worry (cognitive concerns about test performance) and emotionality (autonomic reactions to testing) related to high, medium, and low performance expectations. They found that worry was inversely related to performance expectations while emotionality was not significantly related. The sample size for high expectation was small (n=9), the data were correlational and there was no measure of test performance. Despite the limitations of the study, the component that significantly related to expectations was worry. The worry may have disrupted mindfulness.

What had yet to be created was a reliable and valid measure of test anxiety and its components. Spielberger, Gonzales, Taylor, Algaze and Anton (1978) developed a measure called the Test Anxiety Inventory (TAI). The TAI was based on the work of Leibert and Morris (1967) suggesting worry to be the main problem in test anxiety and included two dimensions of test anxiety – worry and emotionality. Sarason (1984) argued that test anxiety was too complex to limit to two factors. He agreed that anxiety is comprised of cognitive and emotional factors

and the cognitive factors seem to be the most damaging, but there are also behavioral and physical (bodily reactions) components of test anxiety. Sarason (1984) built his four-factor model of test anxiety based on the relationships between reactions to tests and cognitive interference. After conducting a principal components factor analysis on survey data collected from 390 undergraduates, Sarason distinguished between 4 components of test-anxiety. Worry was divided into worry and test irrelevant thinking and emotionality was divided into tension and bodily reactions. Again we see components that would be disruptive to mindfulness – test irrelevant thinking disrupting attention and worry perhaps disrupting intention. Intentionality is difficult when a person is busy worrying. This work led to the eventual development and validation of the Revised Test Anxiety (RTA) scale in the early '90s (Benson & El-Zahhar, 1992; Benson & El-Zahhar, 1994) which measures the four factors of test anxiety.

McIlroy, Bunting and Adamson (2000) conducted a correlational study among 117 psychology students that compared exam scores with test anxiety reported on the RTA. Students were from first year, second year and fourth year classes and they were kept in 3 separate groups based on their program year due to different exam schedules. First and second year students had 6 exams, so both average exam scores and individual exam scores were compared. Fourth year students had many more exams, so only averages were compared. Test anxiety was explained by McIlroy et al. as a form of state anxiety because it is present when there is an evaluative experience. However, they also suggested that the high prevalence of tests in college may make test anxiety appear more like trait anxiety. They found the cognitive components of test anxiety were consistently negatively associated with poor performance. Worry was defined as the negative evaluative thoughts about performance and self. The test taker expects low performance, has low confidence and expresses self-doubts. The test-irrelevant thoughts are just

that – non-evaluative, intrusive thoughts that have no relevance to the exam. This we could call the distracted test taker. Again, a clearer rendition of the disruptive cognitive components of anxiety points to disruptions in attitude and attention.

McIlroy et al. (2000) found that the emotionality components did not consistently relate to exam performance. For first and second year students, negative correlations with tension were found with all 6 exams, but only two were significant. Correlations with bodily symptoms were not significant and they were sometimes positive and sometimes negative. They defined tension as the psychological experience of both the test and anticipating the results. Bodily symptoms were explained by the researchers as the physical reactions to anticipating the test and taking the test. The findings of McIlroy et al. seem to imply that it is cognitive improvements that would make a performance difference, not emotional improvements, as in relaxation.

In intervention studies, we see test anxiety being addressed as a state anxiety problem with techniques being used to improve components of mindfulness just before testing. Based on his factor analysis, Sarason (1984) concluded that in evaluative situations a test anxious person experiences worry and self-deprecation which diminishes his/her level of attention thereby contributing to poor performance. He also found, from an attentional intervention, that task orientation (attention-directing) actually diminished worry and test irrelevant thinking and significantly improved performance on an anagram test. After assessing the levels of worry (high, medium, low) in 180 undergraduates, 60 were assigned to each of 3 groups (2 experimental and 1 control: attention-directing, reassurance, control), but it was not clear if the assignment to experimental groups was random. It was also unclear how many students were found in each level of worry. Sarason attempted to create an evaluative situation by telling the

participants that the anagram test assesses their college level work ability, but was not clear if this experimental manipulation successfully induced stress. Right after reading the anagram test instructions, participants were either told to focus on the task and not be distracted (attention-directing) or to not be concerned about performance (reassurance). The attention-directing group performed at a significantly higher level than the reassurance and control groups, but Sarason failed to examine whether students were able to redirect their attention in a similar fashion during later exams. It appears that there is a greater performance benefit when attention is enhanced than when concerns are quelled.

In 1991, Naveh-Benjamin argued that the nature of test anxiety is different depending on the student. When he conducted an intervention study based on the student differences he found significant academic performance (GPA) differences, at the end of the semester. He proposed that the problem of poor performance lies in the fact that some students know the information well, but experience cognitive interference while other students have a poor understanding of the information thereby experiencing a skills deficit. Students with interference have a retrieval problem and students with a skills deficit have an encoding and organization problem. He concluded that researchers have been successful with reducing anxiety, but not successful at consistently improving academic performance. In his pre-post between groups study, Naveh-Benjamin selected eighty-four high test anxious undergraduates and divided them into two groups based on quality of study skills – good versus poor. Both test anxiety and quality of study skills were measured using reliable and valid measures. These two groups were then randomly assigned to either systematic desensitization (SD), study skills training, or no-training control. This resulted in a total of 6 groups consisting of 14 students per group yielding 2 groups

for systematic desensitization, 2 groups for study skills training and 2 groups for no-training control.

Four 1 hour sessions were conducted by an instructor for both the systematic desensitization and study skills training groups. In SD, students were trained in relaxation, including muscle relaxation, and then in visualization. During visualization they were instructed to imagine certain stressful test situations and then they were told to relax while maintaining those images until stress was replaced with relaxation.

In study skills training, students were trained in methods to improve learning (surveying materials, asking on-topic questions, etc.) and methods for successful exam performance (time management, identifying types of questions, etc.). After learning these methods, students practiced them. The control group simply completed questionnaires at the beginning and end of the semester.

Those students who had poor study skills and were trained to use more effective study skills experienced significant test anxiety reduction and GPA improvement in comparison to those who had poor study skills and received SD. Students who had good study skills and were trained in SD experienced significant test anxiety reduction and GPA improvement as opposed to those who had good study skills and received study skills training. At the end of the study, the controls experienced no significant change in anxiety or performance and the experimental groups differed significantly from the controls in both anxiety and GPA. Sample sizes were somewhat small, but the study highlighted that when a performance focus is taken, anxiety is reduced and performance is enhanced. We see this clearly in the skills training group where components of mindfulness are enhanced. The SD group had more of a focus on enhancing

mindfulness through relaxation. The attitude of the SD group was improved through relaxation in visualization. It appears that it is the performance focus of mindfulness training that causes improvements.

Ramirez and Beilock (2011) conducted a randomized controlled laboratory study clearly demonstrating the impact of a type of cognitive training on performance in a mildly stressful condition. However, without implementing a practical component the laboratory findings could not be generalized to the classroom. Twenty healthy college students were assigned to either a control group or an expressive writing group. At pre-test, the students were given a laboratory math based problem solving task and told to do their best. Performance did not significantly differ between the groups. At post-test, students were subjected to a stressor followed by a performance task. Students were told that they would win money if they improved their performance on the math test and their partner in the effort (who each student was informed about) had already improved, thus winning and losing was entirely dependent on the students. Furthermore, students were told that performance would be recorded and viewed by others. For 10 minutes before the test, writing students expressed their thoughts and feelings about the math test and the control students waited without a task. Students in the writing group performed significantly better than the control group students. The sample size was small and there was no manipulation check for stress and actual college exam performance was not investigated.

The improved math performance in the expressive writing condition indicated that there was a refocusing from anxiety and stress to test taking, resulting in improvement. Having students use expressive writing to focus on test taking in the presence of stress was tested and confirmed by Ramirez and Beilock (2011) when they replicated their laboratory study with a

third group that wrote about an unrelated and unemotional topic. Significant performance results were observed for only the expressive writing group. Beilock suggests that the expressive writing reduces the cognitive category of worry leaving room for enhanced attention. From writing about their thoughts and feelings about the math test, students were able to diminish any anxiety or fear to free them from worry and enhance their mindfulness on the test. Beilock described the expressive writing as a form of exposure to the fear and anxiety that had the worry dissipate.

Earlier research addressed test anxiety as a two component problem with measurements devoted to worry and emotionality (Spielberger, Gonzales, Taylor, Algaze and Anton, 1978). Based on the four-factor model of Sarason (1984), later research addressed test anxiety as a four component problem with a measurement devoted to worry, test-irrelevant thinking and tension, bodily symptoms (Benson & El-Zahhar, 1992; Benson & El-Zahhar, 1994). By using the four component measure to show consistent negative correlations between cognitive anxiety components and performance (McIlroy, Bunting and Adamson, 2000), it is clear that test anxiety is currently conceptualized as a multidimensional problem that impedes performance with cognitive dimensions being the most damaging. In order to improve performance, researchers have taken a logical approach of reducing the cognitive components of anxiety. However, what also arises is an approach that is focused on performance enhancement which is most prevalent in meditation research. The common focus between both approaches is the enhancement of the components of mindfulness. However, what is unique about the performance approach is its apparent applicability even to those students who are not debilitated by test anxiety. If mindfulness is the key to both approaches then is important to first understand the origins of the concept of mindfulness before examining research on mindfulness and test performance.

Meditation

Meditation has its roots in ancient East Asian traditions. Cahn and Polich (2006) offer a definition of meditation as a practice that utilizes specific attention training to self-regulate somatic and mental processes thereby affecting mental states and traits.

Lutz, Dunne, and Davidson (2007) conduct a literature review of meditation and neuroscience of meditation and conclude that researchers often examine Buddhist meditation as opposed to other meditations due to the extensive, descriptive and detailed nature of Buddhist meditation practices. Even though there are a wide range of Buddhist practices, they share common essential features. First, meditation involves induction of a cognitive, emotional, or physical state or set of states that the practitioner can observe. Second, the induced state is coupled with enhancing desired traits and inhibiting undesired traits, whether they are cognitive, emotional or physical. Third, successful meditation requires training and practice.

The ultimate goal of the meditation is mindfulness and awareness. Mindfulness is called stability, consistency of focus, and awareness is called clarity, vivid focus. One could have stability with little or no clarity or clarity with little or no stability. The practice of meditation is aimed at achieving a balance between stability and clarity, i.e. a balance between mindfulness and awareness where consistent and vivid focus are maintained at a high level.

Cahn and Polich (2006) state that the two general categories of meditation -- mindfulness and concentrative -- both have this balance as their ultimate goal. The difference between the two categories is how attention is focused to attain the goal. The mindfulness approach is broad, allowing thoughts, feelings and sensations to enter while maintaining awareness in an unattached

and non-judgmental fashion. What is called the concentrative approach is focused on a specific sound, image or breath as a tool for attaining balance. Transcendental meditation (TM), coming from Hindu tradition, uses the concentrative approach, but with the goal of attaining the balance without needing specific tools. The mindfulness approach does not use specific tools, so it appears that TM is about ultimately becoming skilled at the mindfulness approach by starting with the concentrative approach.

In their literature review, Lutz, Dunne, and Davidson (2007) conclude that the most widespread meditation practices (Insight meditation in Buddhism, Zen of Japan, and Tibetan tradition) utilize breathing to develop the stability and clarity – the goal of meditation. They all implement attention to breathing, recognition of lack of attention on breathing, and redirection of the attention to the breath. In Buddhist Insight meditation, the stability comes from recognizing the lack of attention and redirecting it and the clarity comes from the attention to breathing.

Lutz, Dunne, and Davidson (2007) explain that self-report measures of meditation are used to determine levels of stability and clarity and to compare the meditative state and the post-meditative state. Stability is the degree of uninterrupted presence one has to his/her intended state. Said another way, it is the amount of time one is focused on or present to their induced state. Clarity is the subjective intensity of a state or how vivid the state is for the meditator.

The comparison measure comes from a shift in the trait(s). If inducing a state is connected to traits then there should be a trait effect that is produced during meditation. Looking at changes (cognitive, emotional, or physical) between the meditative and post-meditative states will show this effect. Lutz, Dunne, and Davidson (2007) conclude that self-reports have been useful for observing the specific components of meditation, but there is little precision.

Experienced meditators and novices understand stability and clarity differently and shifts in meditative states are also not understood well between these groups. However, through precise questions on self-reports of experienced meditators science has gained more understanding as to the essential factors that make up meditation. With more precise technology in brain imaging, we may eventually be able to observe the accurate effects of these factors on the brain.

Measuring stability, clarity and balance has not been a focus of neuroscience studies as much as comparing effects of meditation on meditators and non-meditators or novice meditators. Cahn and Polich (2006) state that there is a lack of clarity concerning neurophysiological changes linked to meditation. This prevents measurement of precise components of meditation.

Cahn and Polich provided a detailed review and meta-analysis of studies that examined specific brain regions involved in meditation practice. From EEG studies, theta, alpha and gamma rhythms have been linked to various states associated with performance. Increases in theta activity have been found in the anterior cingulate cortex, medial prefrontal cortex or dorsolateral prefrontal cortex, which are all associated with attention demanding tasks and state and trait anxiety.

Alpha power increases are associated with relaxation from decreased blood flow in inferior frontal, cingulate, superior temporal and occipital cortices. These power increases are found specifically in the right hemisphere from mindfulness meditation training. This locus of increase is of interest because of the possible implications of hemisphere activation. Increased power means decreased activation indicating that the left hemisphere has greater activation relative to the right hemisphere. Greater left hemisphere activation is linked to approach-oriented emotion while greater right hemisphere activation is linked to withdrawal-oriented

emotion. A person with left hemisphere activation will be more likely to approach a stressful situation as a challenge while right hemisphere activation would mean avoidance of the stressful situation.

Gamma rhythms are typically associated with higher mental activity. When meditators and controls were exposed to aversive movie clips, meditators were found to have less frontal gamma power increases (Aftanas & Golocheikine, 2005). This may indicate stability of emotion meaning that the meditator is more capable of controlling his/her emotions as opposed to being controlled by them (Kabat-Zinn, 1990 as cited by Cahn & Polich, 2006).

From PET studies, meditation has been linked to increased blood flow in the frontal and occipital areas and cerebral flow is positively related to overall arousal. In fMRI studies, meditation has been linked to increased activity in the frontal and parietal cortices which have to do with attention. Increased activity has also been found in the limbic system, midbrain, and pregenual anterior cingulated cortex which help with arousal and autonomic control. These three areas also play a role in mood regulation.

What we do know is that meditation has an effect on specific areas of the brain that are involved in attention, anxiety, problem solving and emotion regulation. This effect gives us a clear indication of how meditation may work to enhance cognitive components of mindfulness and therefore test performance. The effect would be an improvement in attention, problem solving and emotion regulation and a reduction in anxiety through cognitive practices leading to performance enhancements.

Meditation and Test Performance

In the 1970's, meditation and relaxation techniques were explored as methods to reduce test anxiety, because of their connection to attention enhancement (Linden, 1973). Being that test anxiety was explained as a problem of attention, these widespread meditation practices were implemented in hopes of achieving lower anxiety, better concentration and improved performance. Linden conducted a well designed experiment for training third graders in meditation to ultimately enhance reading achievement. Test anxiety decreased and attention increased, but achievement did not change.

Due to poor research design, studies of meditation and test/academic performance did not seem encouraging. However, in 1999 Hall conducted a well designed study with 56 healthy undergraduates. It was an experiment that involved training in Transcendental Meditation (TM) where half of the students were randomly assigned to meditation or a no meditation active control. For a semester, each group met twice a week for one hour to have a "group study" session. The meditation group started and concluded with 10 minutes of meditation while the control group just studied. Meditation consisted of training techniques in breathing, relaxation and attention-focusing. Stability and clarity were developed through practicing breathing techniques and attention-focusing. There was a significant increase in GPAs between groups at the end of the semester for those who were trained in meditation in comparison to the control group GPAs. Even though it was clear that meditation made a difference for student academic performance it was not clear what components of the meditation were critical for this improvement.

Kirkland and Hollandsworth (1980) proposed that poor test performance is a result of a skills or cognitive deficit as opposed to test anxiety and this cognitive deficit can be corrected

with cognitive training. They randomly assigned 60 test anxious undergraduates (reliability and validity of test anxiety measures was not provided) to four groups of 15 participants - test-taking skills acquisition, relaxation, meditation, or active control groups. After five 90-minute training sessions, students in the skills acquisition group (effective test-taking strategies, adaptive self-instructional statements, and attention skills), in comparison to the other techniques, performed significantly better on an anagram test and their GPA significantly improved. Comparisons of group means revealed that meditation and relaxation had no significant impact on anagram performance or on GPA.

What was not clear was if what was called meditation was in fact meditation. There was a general statement of meditation being cognitive, but there was no mention of how meditation instruction was conducted. However, the skills acquisition training seems to be in line with at least the cognitive components of meditation practices. Skills training could be viewed as a technique for establishing mindfulness and awareness through test-taking strategies, self-instructional statements and attention skills. It appears that balance between mindfulness and awareness of test-taking skills is the ultimate goal and can be achieved through skills training. Mindfulness meditation has balance as the goal, but in a broader sense with relaxation through breathing playing a role in achieving the balance. It may have been that what they were calling meditation was more like relaxation with attenuated cognitive components. A true mindfulness meditation practice was missing from this study.

More recently, Tang et al. (2007) randomly assigned 80 healthy undergraduates to integrative body-mind training (IBMT) or a relaxation group. The study was both pre-post and between groups to determine if IBMT would improve attention, self-regulation and test

performance for college students. IBMT consisted of training in relaxation, breathing, mental imagery and mindfulness. Relaxation training was conducted with progressive muscle relaxation where muscle groups are tensed and relaxed progressively to enhance relaxation. Training took place in a lab from an instructional recording, with an instructor present, followed by 5 days of practice for 20 minutes a day. The test administered was the Raven's Progressive Matrices and prior to administration a mental arithmetic task (counting backwards by progressively subtracting 47 from a four digit number for 3 minutes) was given to induce stress. Stress was checked both with self-report and a physiological measure of cortisol levels. They found significantly enhanced attention, self-regulation and test taking outcomes in the IBMT group both pre-post test and in comparison to the relaxation control group. The missing component of this study was a check for generalizability to actual exam performance.

These studies share components of mindfulness in the interventions that were used, but none of them focused on observing the impact of only mindfulness on performance. Both laboratory test improvements and academic improvements have been demonstrated, but only Kirkland and Hollandsworth (1980) observed them in the same study. One cannot deny that the improvements seem to be due to cognitive training as opposed to relaxation much like the test anxiety research. However, what is missing is a study on mindfulness that replicates the findings of Kirkland and Hollandsworth. This would enable us to conclude that mindfulness improves test performance and relaxation is not needed for this improvement to be achieved.

Mindfulness

From the theoretical literature on mindfulness, it appears that the definition of skills-acquisition by Kirkland and Hollingsworth (1980) maps on to a proposed theory of mindfulness.

Skills-acquisition seems to be the application of mindfulness to test taking. It is really only in the last decade that mindfulness has been used in the research on test performance and it is only in the form of correlational or theoretical work. If mindfulness has been part of randomized controlled studies it has merely been incorporated into the experimental techniques as opposed to being used alone (Hall, 1999; Tang et al., 2007).

In 2006, Shapiro, Carlson, Astin and Freedman, in a theoretical article, defined mindfulness according to Kabat-Zinn – "paying attention in a particular way: on purpose, in the present moment, and non-judgmentally." Shapiro et al. proposed that this definition possibly highlights the three critical components of mindfulness – intention, attention and attitude (IAA). "On purpose" is intention, "paying attention" is attention and "in a particular way" is attitude. This theory is cautiously proposed by Shapiro et al. because it has not been tested, but if we look back at the definition of skills-acquisition we have to wonder if it is in fact the cognitive skills training of mindfulness that is causing enhanced performance. This could mean that cognitive skills training is synonymous with mindfulness training. Effective test-taking strategies provide intention, attention skills develop attention and adaptive self-instructional statements train attitude. Kirkland and Hollandsworth (1980) were not merely training students in test skills; they were training students to be purposeful, to pay attention and to develop a non-judgmental, positive attitude.

Relaxation

One could propose that it is the combination of relaxation and mindfulness that is producing the enhanced performance in the studies conducted by Tang et al. (2007) and Hall (1999), but Lutz, Dunne, and Davidson (2007) explain that meditation is not relaxation. Lutz et

al. describe the role that relaxation plays in meditation. Relaxation may be necessary to ease physical and/or mental tension, so meditation is possible, but relaxation, according to Buddhist tradition, can be harmful. If a person becomes too relaxed this can lead to dullness. An excess of dullness is said, in Buddhist tradition, to be the quality that leads to inactivity and depression. In order to prevent this dullness from arising, meditation is practiced in positions other than lying down. At best, relaxation would be a prerequisite for meditation.

In the study conducted by Tang et al. (2007) relaxation was used in the IBMT group, but as a means to support building focused attention. TM works in a similar manner by using a sound, image or breathing to attain this heightened attention which may have caused the students in Hall's (1999) study to achieve better GPAs in the end of the semester. Thus, relaxation may be an important prerequisite for enhancing mindfulness to improve performance, but Kirkland and Hollandsworth (1980) enhanced performance with only cognitive skills training.

Mindfulness and Test Performance

No studies to date have investigated the effects of mindfulness training on test performance. In 2008, Paterniti completed her dissertation on the comparison of mindfulness and skills-training for reducing test-anxiety. She randomly assigned 48 students (undergraduate and graduate) to a mindfulness group or skills-training group. No control group was used. Both interventions reduced total test anxiety, worry and emotionality, but no measure of academic performance was utilized.

Pilot Study

As part of a class based research project, 32 undergraduate psychology students were randomly assigned to a mindfulness intervention and an active control. Seventeen students listened to a mindfulness meditation recording and 15 listened to relaxing music. Relaxing music was used as an active control as research consistently shows that exposure to certain music can lower anxiety (Labbe, Schmidt, Babin & Pharr, 2007). Following stress induction, the mindfulness group performed significantly better on the Raven's Advanced Progressive Matrices (APM; 1938), a test of complex visual-spatial reasoning. These findings were consistent with those reported by Tang et al. (2007).

Statement of the Problem and Hypotheses

No published study, to date, has investigated the role that mindfulness plays in performance enhancement despite its clear presence in the literature. Drawing upon previous research on test anxiety and findings from a pilot study, this study investigates whether mindfulness meditation can help students perform better on tests in the face of stress and if improved performance is due primarily to mindfulness training or the combination of mindfulness and relaxation training. Due to the aforementioned mapping of a mindfulness theory onto cognitive skills acquisition, I am considering mindfulness training to be synonymous with cognitive skills acquisition. This cognitive training was considered to be a precise application of mindfulness to test performance. Based on the findings presented above, I expect that the mindfulness group will have higher performance on both laboratory and course tests than a music relaxation group that reliably reduces anxiety. I predict no differences between the mindfulness and skills acquisition groups. It is my hope that the data will provide information

that can be used to develop effective interventions for college students who wish to improve performance.

Method

Participants

The sample consisted of 56 undergraduate students recruited from biology, chemistry, statistics, and business courses. Thirteen different majors were represented even though recruitment took place from only 4 general subject categories. Of the total sample, 18 received training in guided mindfulness meditation, 18 received training in guided cognitive skills acquisition, and 20 were given a relaxing piece of recorded music. The sample consisted of 37 females and 19 males with the majority being freshman, sophomores and juniors (See Table 1 for class status samples and percentages). In terms of race, the majority was Caucasian (26), Asian (13) or African American (11).

Design Strategy

A three-group, between groups randomized design was used to investigate the effects of mindfulness meditation, cognitive skills acquisition (mindfulness) and relaxing music on test performance. Music was chosen as the relaxation control with which to compare the mindfulness groups because of the work of Labbe, Schmidt, Babin and Pharr (2007) in which lower anxiety was produced through music induced relaxation. The cognitive skills acquisition group was constructed in order to isolate separate the cognitive components of mindfulness from relaxation. Mindfulness meditation was designed to be a synthesis of both cognitive skills and relaxation.

Materials

Three separate training recordings were created to be used for self-instruction. The first was obtained from the Mindful Awareness Research Center (MARC), an affiliate of University of California, Los Angeles' Semel Institute (MARC, 2009). The instruction included breathing, relaxation and attention to the surroundings. Listeners were asked to accept whatever thoughts, emotions or body sensations they experienced as opposed to trying to block them out. The second was created from the transcript that Kirkland and Hollandsworth (1980) designed for their study. An overview of essential test taking strategies was presented and listeners were instructed to think about how they would apply them. They were also given an explanation of positive self-evaluation and on-task statements versus negative self-evaluation and off-task statements. An example of positive self-evaluation would be, "I know I can do as well as anyone on this test," while a negative self-evaluation would be, "Everyone here is smarter than me." An example of an on-task statement would be, "I remember seeing that name in my book," while an off-task statement would be, "I wonder what my date will be like tonight." Examples of the positive self-evaluations and on-task statements were focused on and the listener was instructed to construct his/her own. The third was obtained from Tibetan Singing Bowls (Inner Calm Audio, 2008). This was a soft style of percussion music used for inducing relaxation. It was a slow rhythm of a spectrum of high and low chime and gong sounds.

Measures

The Revised Test Anxiety (RTA) scale developed by Benson and El-Zahhar (1994) was used to assess trait test anxiety across four distinct cognitive and emotionality components. The RTA consists of 20 statements from 4 distinct categories – worry, test-irrelevant thinking,

tension and bodily symptoms. Examples of statements are, "I worry a great deal before taking an important exam" and "While taking a test my muscles are very tight." Each statement is measured on a Likert scale that ranges from 1 - almost never to 4 - almost always. Lower scores indicate less test anxiety. Scale reliability was determined from a multinational sample consisting of 202 graduate and undergraduate American students and 360 undergraduate Egyptian students. Overall scale reliability is 0.89. Worry subscale is 0.71, tension is 0.84, test-irrelevant thinking is 0.74 and bodily-symptoms is 0.78 (Benson & El-Zahhar, 1994). From cross-validation using two random samples of 281 students, stability of the dimensionality of the RTA was found (Benson & El-Zahhar).

Items drawn from the Relaxation Technique Rating Scale (Greenberg, 1999) were used to assess whether participants felt relaxed after their daily practice and to compare the groups on their self-reported levels of induced relaxation. Selected items included statements like, "I was able to close out my surroundings while practicing this technique" and "It made me feel relaxed" and "I felt tired after practicing this technique." The three selected examples of statements were intended to provide self-reported measures of focus and tiredness in addition to relaxation. Tiredness was equated with vigor which would seem to accompany enhanced mindfulness as would focus. Participants were asked to rate the extent to which each statement applied to them on a Likert scale that ranged from 1 – very untrue to 5 – very true. Higher scores are more indicative of greater relaxation. We added 2 items to this scale to assess the participants' adherence to the training. Reliability and validity of this measure have not been assessed formally, but it continues to be widely used as a measure of self-reported relaxation. This measure was used as a manipulation check for compliance with practice instructions.

Selected items from the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1971), were used to assess self-reported stress during laboratory procedures. The majority of the words drawn, "anxious" and "annoyed," came from the Tension subscale (e.g., anxious, annoyed, relaxed), but we included words such as "efficient" and "relaxed" to assess perceptions of cognitive state. The participants rated each word as it applied in the current moment on a Likert scale ranging from 0 – not at all to 4 – extremely. Several abbreviated forms of the POMS exist, such as the POMS-Brief and POMS-Short Form, many of which have been accepted as reliable and valid. Focusing on the measure in its entirety, McNair et al. (1971) found it to possess internal consistency of $\alpha = 0.63$ to 0.96 ($p < .001$) as well as concurrent and predictive validity. The POMS has also been validated with physiological measures, e.g. heart rate and blood pressure induced with cocaine (Fischman, Shuster, & Hatano, 1983).

Raven's Advanced Progressive Matrices (Set II; Raven, 1962) was used to measure cognitive performance. RAPM consists of 36 spatial reasoning tasks in which one must choose the ninth image that completes a pattern from a list of 8 options. The matrices are divided into three sets and are arranged in order of increasing difficulty. I randomly selected three problems from each of the three sets. Each problem was scored as either correct or incorrect. This measure is found to have split-half reliability ranging from 0.80 – 0.90 and test-retest reliability of 0.83 (Arthur & Day, 1994; Bors & Forrin, 1995). Concurrent validity coefficients between the APM and the Otis I. Q. and Weschler scales 0.75 and 0.74 (McLaurin, Jenkins, Farrar, & Rumore, 1973 as cited by Bors & Stokes, 1998).

Procedure

Study participants were recruited from 8 different undergraduate classes at Emory University. Only classes with multiple exams were chosen, so that the practical application of techniques on high stakes performance could be analyzed. Students were recruited from statistics, biology, chemistry and business classes. Eighty-nine students volunteered with thirty-one (34.8 %) choosing not to start the study. Two additional participants did not complete the final assessment resulting in a total of 56 participants. Another 5 participants were lost because exam scores were not available. The total by the end of the study was 51 students.

Participants were recruited at the beginning of class sessions and indicated their interests by registering for a training session. Volunteers were randomly assigned to mindfulness meditation, cognitive skills acquisition or music relaxation. Training in the assigned technique was conducted by the principle investigator or a research assistant in a research laboratory. Before training began, informed consent was obtained and participants completed a demographic sheet and the RTA (Revised Test Anxiety) scale. The consent form explained the purpose of the study and possible benefits to the participant. It also clearly stated that the participant had the right to discontinue the study at any time and in case of inquiries the necessary contact information was provided. Participants also provided consent for the investigator to obtain their score on their first course exam after completing training and one week of practice.

Each training session lasted for approximately 30 minutes. Participants listened to a standardized recording of the technique assigned. Following training, participants were asked if they had any questions of needed any clarification. After answering questions and providing clarification of techniques, the instructor gave each participant a compact disc of the recording and instructed participants to listen to the recording once each day for one week.

Participants were contacted via email each day to remind them to practice and to request that they complete an online log after practice. The log consisted of questions about the length of practice and questions from the Relaxation Rating Scale (RRS).

Participants returned to the laboratory one week following their initial training. In the second session, investigators administered a moderate stressor, a manipulation check, and the Raven's Advanced Progressive Matrices. One investigator administered the mild stressor and manipulation check and another investigator administered the test.

To induce stress, the participant counted backward as fast as possible out loud by 3's starting at 100. At any hesitation, the investigator asked the participant to begin again. Most participants repeated the counting procedure 5-6 times over a period of two minutes. After counting, the participant completed the POMS and moved to a second room where a different investigator administered the Ravens Progressive Matrices.

Upon completion of the RAPM, participants received $20 and were debriefed. Some participants stated spontaneously that they were relieved to know that the counting was designed to elicit stress because it had frustrated them. Others stated that they found themselves using the techniques they had learned from the skills training in their other classes. They were invited to ask questions and thanked upon conclusion of the debriefing.

After course exams took place, professors provided exam scores that were recorded with identifying information removed.

Results

Random assignment to groups was evaluated with a series of Chi-square Tests of Independence comparing social demographic variables across groups. No significant group differences were observed for any of the variables. A statistical trend for year in the college, χ^2 (6, N = 56) = 12.139, p = 0.059, showed that there were somewhat more freshmen (n = 11) in the music group than in the meditation (n = 4) or skills (n = 8) group. When year in college was dichotomized into upper and lower class status, the distribution across groups was balanced, χ^2 (2, N = 56) = 2.548, p = 0.280. One-way analysis of variance (ANOVA) revealed no significant group differences in overall test-anxiety, F(2, 53) = 1.08, p = 0.35, or the four factors of test-anxiety (See Table 2 for means and standard deviations). The means for total test anxiety and for each of the 4 components of test anxiety were not significantly different from population norms. However, there was a trend for higher overall test anxiety (t(55) = 1.75, p = 0.09, d = 0.23) and tension (t(55) = 1.86, p = 0.07, d = 0.25).

Between groups one-way ANOVA was used to compare groups on their respective amounts of practice. No statistically significant differences in group means, F(2, 52) = 1.51, p = .231, η^2 = 0.06, were observed,. The average practice was between 5 and 6 days for each of the three groups, suggesting good program compliance (See Table 3).

Study participants self-reported their levels of induced relaxation, focus and tiredness from practice each day when they completed their online logs. Planned contrasts were conducted to determine if there were predicted group differences in self-reported levels of induced relaxation. The Levene's test for homogeneity of variances was significant, so planned comparisons were conducted with separate variance estimates. Music was predicted to have higher levels of relaxation than mindfulness meditation and skills and mindfulness meditation

was predicted to have higher relaxation than skills. Self-reported levels of relaxation were significantly higher in the music group than in the mindfulness meditation group and the skills group, $t(45) = 2.214$, $p < 0.05$, $d = 0.74$. The mindfulness meditation group was significantly higher in self-reported relaxation than the skills group, $t(26) = 2.112$, $p < 0.05$, $d = 1.10$.

Planned contrasts were examined to determine if there was a significant group differences in average levels of self-reported induced focus from practice. Participants in the music group were expected to report lower levels of focus than both mindfulness meditation and skills and less self-reported focus than mindfulness meditation. The Levene's test was significant, so tests were conducted with separate variance estimates. Participants in the music group reported significantly more focus than mindfulness meditation and skills, $t(51) = 1.499$, $p = 0.05$, $d = 0.55$, a finding opposite to prediction.

Planned comparisons also were conducted to determine if there were predicted group differences in reported tiredness from practice. Participants in the music group were expected to have higher self-reported tiredness than those in the meditation and skills groups and those in the meditation group were predicted to have higher self-reported tiredness than those in the skills group. Those in the music group had higher reported tiredness than what was reported by participants in the meditation and skills groups, $t(55) = 1.687$, $p < 0.05$, $d = 0.43$. Participants in mindfulness meditation had higher reported tiredness than those in the skills group, $t(55) = 2.216$, $p < 0.05$, $d = 0.45$.

Program outcome was assessed in both the laboratory and the classroom. The laboratory task required participants to complete a complex visual-spatial task under mild stress. According to self-reported levels of induced stress, confusion and anger, one-sample tests of means, using

POMS norms, revealed that the experimental manipulation left participants highly stressed, $t(55) = 12.67$, $p < 0.001$, $d = 1.69$ and confused, $t(55) = 14.14$, $p < 0.001$, $d = 1.89$ and mildly angry, $t(55) = 3.30$, $p < 0.01$, $d = 0.44$. One-way between groups ANOVA yielded no statistically significant group differences in self-reported stress ($F(2, 53) = 1.85$, $p = 0.17$), confusion ($F(2, 53) = 2.05$, $p = 0.14$), or anger($F(2, 53) = 1.00$, $p = 0.38$). One-way between groups ANOVA was conducted to analyze performance on the visual-spatial task between groups. No significant differences between groups on the matrices were found, $F(2, 53) = 0.54$, $p = 0.59$. See Table 5 for group means and standard deviations and effect sizes. Analyses were repeated excluding participants (n = 5) who practiced only 3 or fewer days. Again, no statistically significant group differences in performance were found, $F(2, 48) = 0.50$, $p = 0.61$. One-sample test of means, using general college student norms revealed that performance on the RAPM had a trend toward higher performance than the norm, $t(55) = 1.85$, $p = 0.07$, $d = 0.25$. A one-sample test of means, using advanced college student norms revealed that performance on the RAPM was more similar to the advanced college student norms than the general college student norms, $t(55) = 0.808$, $p = 0.42$, $d = 0.19$.

Between groups differences in classroom performance were analyzed with one-way between groups ANOVA. No statistically significant group differences were observed, $F(2, 48) = 0.55$, $p = 0.58$. A one-sample *t*-test comparing the reported *z*-scores for course exams against a mean of zero was not statistically significant, $t(51) = 0.447$, $p = 0.66$, suggesting typical exam performance across groups.

Discussion

Analyses showed that different forms of training were associated with different levels of experienced relaxation, focus and tiredness. Test anxiety was in line with the population norm for college students and practice compliance was high. Under moderate stress, all groups performed equally well on a complex visual-spatial task and all groups performed equally on classroom exams. The hypotheses of this study were not supported by the findings. No treatment resulted in significantly different performance on a laboratory based test or a classroom exam. Manipulation checks were analyzed with planned contrasts to determine if there was a weakness in the experiment or if there was a theoretical problem with mindfulness.

Self-reported levels of relaxation following practice were found to be significantly higher in the music group than the mindfulness meditation group and the skills group. The mindfulness meditation group self-reported a significantly higher level of relaxation than the skills group. The mean level of relaxation reported by the skills group fell between 3 and 4. A rating of 4 for the statement of "The practice made me feel relaxed" was labeled "Somewhat true" while 3 was labeled "I'm not sure." The skills group was designed to capture cognitive mindfulness according to Shapiro, Carlson, Astin and Freedman (2006), who had conceptualized mindfulness as being made up of only cognitive components – intention, attention, attitude. The mindfulness meditation group was designed to serve as a synthesis of mindfulness and relaxation, comprised of the techniques found in Hall (1999) and Tang et al. (2007). However, in order for this synthesis to reflect mindfulness as it is understood by Shapiro et al., the mindfulness meditation group could not differ significantly from the skills group or the music group according to self-reported levels of relaxation, focus and tiredness(vigor). Otherwise, mindfulness meditation would be more like a cognitive technique or relaxation technique respectively. Mindfulness meditation did report significantly higher levels of relaxation than skills, so it seems to have

functioned more as a relaxation technique in this respect. This suggests that the trainings of this study were most similar to those found in Kirkland and Hollandsworth (1980) – a cognitive training group compared to multiple relaxation groups. However, comparisons of focus and tiredness were done before concluding that mindfulness meditation was merely another relaxation technique.

The music group was predicted to have less focus than both mindfulness meditation and skills, but students self-reported significantly more focus than mindfulness meditation and skills which means that music did not function as a control, rather more like a third technique. Even though mindfulness meditation was significantly higher in relaxation than skills, it cannot be concluded that it was merely another relaxation technique due to the fact that music induced high levels of self-reported focus. The mindfulness meditation technique needed to be compared to a relaxation control in order to determine if it was a synthesis of relaxation and cognitive training. Relaxation and focus were higher for the "control" than for mindfulness meditation and skills. This was an unexpected finding that raises the question of how students use music. It could be that students are accustomed to listening to music while studying, doing projects, writing papers, etc., so that they can relax and focus. Music may be the most familiar technique that students use to improve their productivity levels.

Schellenberg (2005) concluded from a brief research review that music listening can lead to enhanced performance on problem solving tasks, but the performance is mediated by arousal and mood. Music that was upbeat and age appropriate was shown to induce the highest levels of arousal and the most positive moods as compared to classical music. Music does not have a

lasting effect from short-term exposure, but long-term music lessons seem to indicate greater performance effects.

The music group self-reported significantly more tiredness than both mindfulness meditation and skills and mindfulness meditation reported significantly more tiredness than skills. To summarize, participants in the music group reported that they were relaxed, focused and tired; those in the mindfulness meditation group reported being relaxed, but not focused or tired following practice; those in the skills group were not relaxed, focused or tired. It may be that the technique which is most familiar, i.e. music, induces the highest levels of self-reported focus. This implies that higher levels of focus require more familiarity, i.e. more practice. The technique which is the next most familiar would be mindfulness meditation because of the relaxation component. Skills would be the least familiar because of having no relaxation component and only new techniques. The studies of Hall (1999), Tang et al. (2007), and Kirkland and Hollandsworth (1980) included guided instruction for every practice session, so this may be what was needed for the current study to ensure complete understanding and proper practice of techniques.

If music enhances relaxation and focus then why does it result in higher levels of tiredness than the other two groups? It could be that students use music when they are involved in a task, therefore taking away the respective task leaves them with nothing to do and they report tiredness. They were asked to do nothing while listening to the techniques; lacking a task may in fact be the reason they reported higher levels of tiredness than the other two groups. Mindfulness meditation and skills training were new techniques, thus there was some element of a task present. The relaxation of mindfulness meditation may be why the mindfulness

meditation group was higher in tiredness than skills. Skills may have been totally new, resulting in no reported tiredness.

It seems that this study required guided instruction for each practice session to ensure understanding and proper practice. What is evident is that self-reported states of mind (focus and tiredness) were reported from each technique. Music enhanced focus, mindfulness meditation enhanced vigor (absence of tiredness) and skills resulted in high vigor. This was an experiment that had a weakness in that there was no active control to which the two experimental techniques could be compared.

The pilot study conducted on psychology students enrolled in a statistics class found that those in the mindfulness meditation group performed significantly better on the RAPM than the music group. Perhaps this difference reflected an expectation that the mindfulness meditation group would improve their performance more than the music group. Psychology students tend to know more about mindfulness from classes like positive and abnormal psychology whereas music is not taught as a technique for enhancing behavior and performance.

Performance on the RAPM, in the current study, was somewhat higher than general college student norms and almost equal to advanced college student norms reported for the test (Raven, Court & Raven, 1977). With no statistically significant differences in RAPM scores across groups, these comparisons to norms suggest that all three techniques helped students maintain a high level of cognitive performance despite being stressed, confused and frustrated/angry while taking the test.

Limitations

No physiological measures were used in this study to examine cortisol levels, heart rate and blood pressure. Even with self-report measures that are validated with physiological measures, there is still error involved. Tang et al. (2007) used measures of cortisol levels to verify induced stress and the technique they used for inducing stress was comparable to the one used in this study. Yet, having only self-report measures keeps the findings limited.

There was no guided instruction for every day of practice. Unfortunately, schedule constraints did not allow for guided instruction every day of practice, so it was assumed that guided instruction on training day would be sufficient. The basis for this assumption was from the pilot study findings that were from guided instruction only being conducted on training day.

Future Research

In order to conduct this study in a successful manner, a relaxation technique that is unfamiliar to students would need to be used. Progressive Muscle Relaxation was considered, but it was ruled out because it was a technique taught in the college. Alternatively, a non-active control group could be included to determine if these three techniques really do maintain high levels of performance on a laboratory test and typical levels of performance on classroom exams.

Guided instruction in addition to the self-instruction would be needed for every day of practice. This would allow for questions and proper practice of the techniques.

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Table 1

Sample Characteristics

Variable	N (%)
Sex	
Male	19 (33.9)
Female	37 (66.1)
Race	
White	26 (46.4)
Asian	13 (23.2)
African-American	11 (19.6)
Other	4 (7.1)
Hispanic	2 (3.6)
Year in School	
Freshmen	23 (41.1)
Sophomore	12 (21.4)
Junior	18 (32.1)
Senior	3 (5.4)
Pre-training Meditation	
Never	15(26.8)
Almost never	26 (46.4)
Sometimes	13 (23.2)
Regularly	2 (3.6)
Everyday	0

Table 2

Revised Test Anxiety Measures

Worry						
Variables	*N*	*M*	*SD*	*F*	*p*-value	η^2
Music	20	11.85	3.42	1.980	0.148	0.07
Meditation	18	11.50	3.09			
Skills	18	13.78	4.52			
Test-Irrelevant Thinking						
Variables	*N*	*M*	*SD*	*F*	*p*-value	η^2
Music	20	6.95	2.96	0.104	0.902	0.004
Meditation	18	7.28	3.10			
Skills	18	7.33	2.33			
Tension						
Variables	*N*	*M*	*SD*	*F*	*p*-value	η^2
Music	20	13.45	3.52	0.037	0.963	0.001
Meditation	18	13.72	2.37			
Skills	18	13.67	3.71			
Bodily Symptoms						
Variables	*N*	*M*	*SD*	*F*	*p*-value	η^2
Music	20	6.40	1.19	2.532	0.089	0.09
Meditation	18	7.50	2.46			
Skills	18	8.22	3.49			
Total Test Anxiety						
Variables	*N*	*M*	*SD*	*F*	*p*-value	η^2
Music	20	38.65	8.17	1.075	0.349	0.04
Meditation	18	40.00	7.68			
Skills	18	43.00	11.63			

Table 3

Practice and Relaxation Checks

Practice

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	20	5.75	1.41	1.51	0.231	0.055
Meditation	17	5.00	1.32			
Skills	18	5.61	1.38			

Relaxation

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	20	4.35_{a}	0.53	4.736	0.013	0.15
Meditation	17	$4.23_{a, b}$	0.51			
Skills	18	3.67_{b}	0.99			

Note. Different subscripts indicate significant group differences via Tukey post-hoc comparisons

Table 4

Stress Manipulation Checks

Stress

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	20	2.10	0.77	1.850	0.167	0.07
Meditation	18	2.00	0.86			
Skills	18	1.63	0.72			

Confusion

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	20	1.83	0.69	2.050	0.139	0.08
Meditation	18	2.25	0.86			
Skills	18	1.78	0.77			

Anger

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	20	0.55	0.67	1.000	0.375	0.04
Meditation	18	0.44	0.66			
Skills	18	0.25	0.65			

Table 5

Laboratory and Classroom Test Performance

APM

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	20	5.70	1.98	0.535	0.589	0.02
Meditation	18	5.06	2.01			
Skills	18	5.50	1.93			

Z-scores

Variables	*N*	*M*	*SD*	*F*	*p*-value	η²
Music	18	-0.08481	1.24	0.546	0.583	0.02
Meditation	15	0.14875	1.11			
Skills	18	-0.23994	0.92			