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Feasibility of a Meditation Video Game to Reduce Anxiety in College Students

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Abstract:

***Background*:** Meditation is a common intervention for college students suffering from issues with anxiety. Due to this popularity, several meditation-based video games have been released which can be used to supplement or motivate meditation practice. However, these tools are not often given scrutiny in a laboratory setting before being released to the public. Our lab conducted a brief feasibility pilot study to investigate Meditation Deathmatch, an open-source meditation video game aimed at stimulating meditation practice. Usability, and Efficacy were assessed to determine whether Meditation Deathmatch might provide an appropriate and effective means of introducing students to meditation.

***Methods*:** 42 undergraduate students in the United States (ages 18-20, M = 18.69, SD = .57) played this game as part of a brief meditation session and completed both pre- and post-training measures of state anxiety as well as the System Usability Scale (SUS) and a short questionnaire assessing attitudes toward meditation.

***Results*:** Participants who received training using Meditation Deathmatch showed significant post-training decreases in state anxiety and consistent and significant increases in game score across trials. These participants also reported high levels of Usability.

***Conclusions*:** Game-based meditation training may be an effective tool for encouraging meditation practice. Further research may work to compare the effectiveness of game-based training to traditional methods and implement game-based meditation training in the treatment of patients with anxiety disorders.

Keywords
Meditation, gamification, anxiety

1. Introduction

The practice of meditation has gained increasing traction as a form of alternative or complementary treatment. Over the last 40 years, varying forms of meditation have been shown to be effective in improving treatment outcomes across a variety of medical [1] and mental health environments [2, 3]. Although meditation as a practice originates from elements of spiritual and religious self-observation, there is a growing field of research which investigates the benefits of meditation from a secular and empirical point of view [4]. This scientific inquiry has led to an explosion of meditation-based products for both corporate and consumer markets [5].

Of particular interest, meditation has begun to see increasing use in higher education as a means to enable students to reduce stress and manage anxiety [6]. Although many such implementations have looked at long-term meditation interventions, often ranging from 8 to 12 weeks in length [7, 8], some recent studies have shown beneficial effects following a much shorter intervention time [9] including preliminary results showing promising results following a single session [10, 11]. However, while the data is clear that meditation would help reduce stress and anxiety among students, it is less clear how best to introduce meditative practices to students so that they will enthusiastically practice and maintain their meditative skills.

In recent meditation literature, this has led to a growing movement to explore the level to which the observed benefits of formal meditation practices (structured breathing, etc.) can be attained through the use of more informal methods of meditative practice, such as present-centered dishwashing [12] and self-compassionate dietary journaling [13]. This involves a theoretical decoupling between formal meditation as a practice and the meditative state which results from this practice, and an emphasis on the importance of the meditative state over any particular meditative action. While this model of meditation is relatively new to the laboratory study of meditation, it has long been common in meditation-based treatment of anxiety which involves the integration of a meditative state into the patient's everyday life [14].

As less focus has come to be placed on formal meditation practice, so too have less formal training methodologies begun to explore the space. As a result, a range of interactive and game-based tools have entered the market aimed at helping users to establish and improve the consistency and effectiveness of their meditation practice. For example, Fernández-Aranda and colleagues [15] successfully reduced anxiety using a game-based intervention to introduce certain meditative concepts, such as mindful breathing and self-compassionate thinking. Additionally, Vidyarthi and Riecke [16] built a tool which helps users to achieve a mindful state through immersive and interactive sound-based technology.

Game-based training represents one promising avenue for the development of training meditation as a skill. Games have been used for training in a variety of environments and for a variety of skills. Research in game-based training has shown a marked improvement in learning and retention, and learners who are adequately engaged in game-based training also report higher subjective enjoyment of the training modality [17]. These effects tend to be most pronounced in situations where there is a high degree of fidelity between the actions taken in the training and the activity which is being simulated [18].

To investigate the effectiveness of game-based meditation training, we used an open-source meditation game named Meditation Deathmatch. Meditation Deathmatch uses the Neurosky Mindwave as an input controller and pits two players against one another to determine which can more consistently achieve and maintain a meditative state [19]. The Mindwave is a single-channel, dry-sensor EEG headset which uses one active sensor placed against the forehead (measuring frontal lobe activity) and one neutral sensor clipped onto the earlobe, which serves as a ground sensor. The headset connects wirelessly with the PC running Meditation Deathmatch through a Bluetooth connection.

The EEG model of meditation used by the program is based on the internal meditation models included in the Neurosky Mindwave software package. This model is fully compliant with traditional neuroscientific models of meditation, such as those covered in Cahn and Polich [20]. The internal model analyzes the raw EEG input for increases in alpha and theta patterns and produces a "meditation value" which ranges from 0-100 and indicates the percentage match of the user's current reading to an exemplar model developed by Neurosky. Meditation Deathmatch takes this meditation value and awards players points based on their percentage match each second which are actively totaled throughout the play session. A screenshot of the game's user interface can be seen in Figure 1.

Figure 1 Screenshot of the Meditation Deathmatch User Interface. In this interface, players' scores are indicated in the blue and orange boxes at the center of the screen. The bars below are moving elements which correspond to proportional levels of each type of brain wave measured by the EEG headset (alpha wave, beta waves, theta waves, etc.). The blue bar at the top of the screen indicates the "meditation value" produced by the Neurosky Mindwave's internal algorithms and the timer in the bottom of the screen indicates the remaining time left in the round.

In this study, we introduced Meditation Deathmatch as a game-based training system for meditation to a sample of undergraduate students. The end goal of this feasibility pilot was to develop a formal paradigm for single session-meditation training with Meditation Deathmatch, similar in time and intensity to those used on other single-session studies [10, 11], which could be used to introduce meditation concepts to students and stimulate further mediation practice. We hypothesized that after practicing meditation techniques with Meditation Deathmatch, participants would (1) display a post-session reduction levels state anxiety and (2) display improvement across trials in their game performance, demonstrating a clear training effect. Additionally, we hypothesized that participants would rate the game highly on measures of system usability.

2. Materials and Methods

This study was evaluated by the Institutional Review Board at the University of Central Florida, under the title "Pilot Test of a Competitive Meditation Training Video Game," IRB Number: SBE-15-11767. Approval was granted on November 24, 2015.

2.1 Participants

42 participants (24 female) were recruited from the undergraduate population at the University of Central Florida (UCF) using the university's SONA system. Participants ranged in age from 18 to 20 (*M* = 18.69, *SD* = .57). Potential participants completed a brief screening questionnaire, and participants who reported a diagnosed seizure disorder were excluded from the study. Participants were compensated with extra credit points for a class in which they were enrolled. Additional demographic information for this sample can be found in Table 1.

Table 1 Sample Demographics.

Gender	Female	n = 24	57.1%
	Male	n = 18	42.9%
	Total	n = 42	100%
Race	White	n = 27	64.3%
	Black	n = 3	7.1%
	Asian	n = 4	9.5%
	Mixed	n = 3	7.1%
	Other	n = 5	11.9%
	Total	n = 42	100%
Ethnicity	Hispanic	n = 8	19.0%
	Non-Hispanic	n = 34	81.0%
	Total	N = 42	100%

2.2 Measures

State anxiety was measured using the State subscale of the State-Trait Anxiety Index (STAI-S) [21]. The STAI is a well-validated measure used to discriminate between state anxiety (current levels of fear, nervousness, and physiological arousal) and trait anxiety (general and enduring tendency to become distressed). The full measure is 40 items, with 20 items assessing state anxiety and 20 items assessing trait anxiety. For this study, only the State subscale was used. Participants were asked to rate statements such as "I feel tense" on a four-point Likert scale. Form Y of the STAI-S was used for this study, which has been shown to be highly reliable with a mean alpha level of .92 [22].

In-game player score was recorded for each trial of Meditation Deathmatch. This score is determined by algorithm in the game which determines how closely the participant's EEG signal matches the internal meditation model, with higher scores indicating greater degree of similarity for a longer period of time [19].

Additionally, Usability for Meditation Deathmatch was assessed using the System Usability Scale (SUS) [23]. The SUS is a 10-item measure frequently used in industry and academic settings to assess the usability of a system. Users respond to statements such as "I thought the system was easy to use" on a 1-5 scale, with 1 indicating "Strongly Disagree" and 5 indicating "Strongly Agree." Item score contributions are summed for all items and multiplied by 2.5, to get an overall score for system usability which can range from 0 to 100, with lower score indicating less usable systems and higher scores indicating more usable systems.

2.3 Procedure

This study followed a single-sample, within-subjects design to establish that playing Meditation Deathmatch improves a participant's levels of state anxiety. All procedures for this study were completed during a single laboratory session conducted at the UCF Psychology Building. These sessions were completed individually with one participant and one researcher. Upon arrival, participants completed a short survey to collect demographic information and to assess baseline levels of anxiety using the STAI-S. Afterward, participants received meditation training utilizing Meditation Deathmatch under the following training protocol.

Each player completed a total of 3 rounds of Meditation Deathmatch, each of which lasted for a total of 3 minutes. The first trial for each participant was intended to take a baseline reading of participants' meditation skill, as measured by the in-game algorithm. For this first trial, participants were provided no instruction on meditation and were asked to look at the screen as the game measured and totaled their scores. Following this baseline, participants were instructed in a 3-minute guided meditation, called the three-minute breathing space, intended to teach the participant meditative techniques for their meditation practice. The three-minute breathing space is a brief exercise which guides participants through the mental processes of non-judgmental mind-body awareness. Afterward, participants completed two additional trials of Meditation Deathmatch. For one trial, participants played a round of the game in the single-player, non-competitive mode. For the other trial, participants were asked to complete a competitive training in which the participant played in two-player mode with research staff and was encouraged to try

to score more points than the researcher. The order of the competitive and non-competitive trials were randomized to prevent order effects.

Finally, after the training protocol had been completed, participants answered a posttest survey assessing state anxiety (STAI-S) and usability (SUS). Participants were then allowed to provide qualitative feedback on the game and the training session. Finally, participants were compensated and provided with a packet of information on opportunities to meditate on campus if they chose to do so.

2.4 Analysis

Statistical analysis for this study was conducted using IBM SPSS Statistics 23. For system usability, SUS scores were totaled and analyzed using measures of central tendency. Mean and standard deviation were calculated and compared against the existing corpus of usability data involving the SUS. Efficacy was computed using 2 repeated measures ANOVAs. The first repeated-measures ANOVA compared pre- and post-test scores on the STAI-S to determine whether a significant change in state anxiety had occurred during the training session. The second repeated-measures ANOVA compared in-game scores across the three trials by trial order for each participant. This analysis was intended to determine if game scores increased as the players gained experience with the game. Finally, a correlational analysis was conducted to link changes in game score with changes in anxiety. For this analysis, change scores were computed from pre-test to post-test for STAI-S rating and from Baseline game scores to Trial 3 game score.

3. Results

3.1 Usability

Scoring on the SUS is expressed on a 100-point scale, and the mean usability rating for Meditation Deathmatch was 79.79 ± 12.49. This score represents an average rating somewhere between “Good” and “Excellent” under the descriptive criteria established by Bangor, Kortum, & Miller [24].

3.2 Efficacy

A repeated measures ANOVA determined that there was a statistically significant difference on the STAI-S ($F(1, 41) = 38.891$, $p < 0.0005$)) between pretest and posttest. Post hoc comparisons revealed that STAI-S scores were reduced between pretest and posttest (37.45 ± 9.27 vs 29.88 ±7.89), creating a mean difference of -7.57 ($p < 0.0005$). See Figure 2 for a graphical representation.

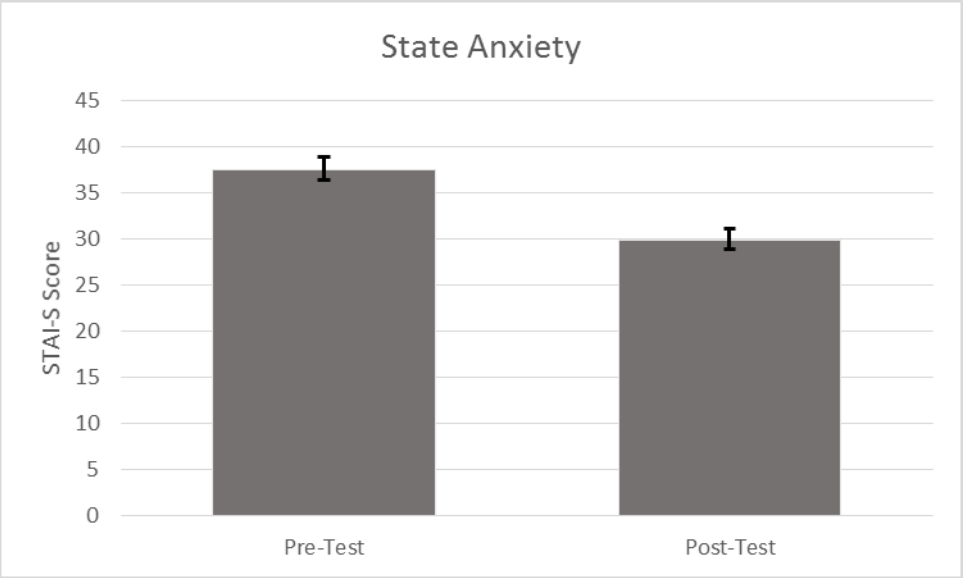

Figure 2 Pre- and Post-Test Ratings of State Anxiety.

For in-game scores, a repeated measures ANOVA was used to determine improvement over the participant's three in-game trials. However, Maunchly's Test of Sphericity indicated that the assumption of sphericity had been violated, ($W = .574$, $p < 0.0005$), so a Greenhouse-Geisser correction was applied. This analysis determined that there was a statistically significant difference in game score between trials ($F (1.402, 57.501) = 38.38$, $p < 0.0005$). Post hoc testing showed that average in-game score increased from a mean of 137.43 ± 138.05 in Trial 1 to a mean of 625.19 ± 429.85 in Trial 3, for a mean difference of 487.76 ± 62.42 ($p < 0.0005$). This improvement is consistent across trials, where there is a significant increase in scores between Trial 1 and Trial 2 with a mean difference of 284.69 ± 33.255 ($p < 0.0005$) and a significant increase in scores between Trial 2 and Trial 3 with a mean difference of 203.07 ± 66.207 ($P = 0.011$). See Figure 3 for a graphical representation of this finding.

Figure 3 Increase in game score across trials (grouped by trial order).

Finally, changes in games score were shown to have a small but significant negative correlation with change in state anxiety levels, r = -.377, p = 0.0014. This indicates that larger changes in game score were associated with greater reduction in state anxiety.

4. Discussion

The results of study provide support the hypothesis that participants who were given training using Meditation Deathmatch would show a significant reduction in state anxiety. This finding suggests that game-based training may be beneficial for individuals who suffer from state anxiety (i.e., those who experience anxiety in specific situations). In the future, healthcare professionals wishing to disseminate game-based treatment supplements may recommend meditations exercises to their patients who suffer from state anxiety. Moreover, designers of games for mental health may consider incorporating game-based meditation practices into their games. Additionally, the results of this study provide support for the prediction that in-game scores would improve across trials indicating that meditation, as measured by Meditation Deathmatch, is a skill which improves with practice.

The results of the present study may suggest that a game-based meditation approach yields promising results. This, in addition to previous studies of informal meditation techniques, serves to bolster the idea that both the benefits of meditation on anxiety and the meditative state are not exclusively elicited by the formal practice of meditation. Kabat-Zinn [14] and other practitioners [12, 13] have long advocated for an integration of the meditative mindset into everyday activities. With the increasing prevalence of video games in society, the evidence provided by this study shows that gaming may be another possible activity which can be utilized to evoke and practice a meditative state. Additionally, these results support the evolving development of single-session meditation training as a means to introducing participants to meditation [10, 11].

Additionally, the results of this study provide some indirect support for the body of evidence of brain-behavior connection in meditation. In this study, participants who had a greater magnitude of change in game score across rounds also tended to experience a greater reduction in subjective state anxiety. As noted previously, these game scores were based on increases in alpha and theta signals measured through the EEG headset. As such, our findings echo previous studies (reviewed by Moore [29]) which have shown reduced levels of anxiety after EEG biofeedback training aimed at altering alpha activity.

However, our findings differ from these previous studies in that previous studies have shown decreased anxiety in response to biofeedback training generally, without regard to whether that training aimed to increase or decrease alpha activity and without regard to the effectiveness of that training in actually increasing alpha activity [29]. Due to the correlation between game scores and anxiety ratings, our results instead indicate that reductions in anxiety are at least indirectly related to increases in alpha activity. This difference may be due to comparison between very short-term training (less than 10 minutes in our study) which induced only state-based changes in alpha, versus the comparatively longer training observed in Moore's review (with total training time ranging from 2-8 hours) which may have induced subtler trait-level changes.

While the results supported the hypotheses, there are shortcomings to the present research design. The most apparent shortcoming is the lack of a control group. Future studies are planned

which will evaluate the results of game-based meditation in a controlled trial against both a control group and a group receiving traditional meditation in order to determine the relative effectiveness of game-based training. However, the current study can only assert a simple post-treatment effect and cannot rule out any placebo effect.

Second, the sample for this study was comprised of college undergraduates with an age range of 18-20 years, potentially limiting the generalizability of the results. Prior research has indicated that gaming preferences and thereby serious game effectiveness varies as a function of a number of demographic variables, including age [25]. While the sample for this study was chosen due to a focus on students in higher education, replication of the present study using a more diverse sample would allow us to draw stronger conclusions regarding the efficacy of the competitive meditation approach to a general population.

Finally, the research was performed using a single-channel EEG headset as a controller. While single-channel EEG is capable of detecting the electrical patterns associated with meditation, it cannot conform to the 10-20 system of EEG measurement. The 10-20 system is the international standard for EEG measurement and refers to the distance between sensors as a function of total surface area of the head [26]. Refinements to the Meditation Deathmatch system are in progress, and future studies using this game will be able to make use of multi-channel EEG headsets which conform to this standard. Unfortunately, the game build used for this experiment did not allow for the simultaneous collection of raw EEG data. This means that great care should be taken when comparing the physiological component of this study to previous neuroscience studies of meditation.

Additionally, careful consideration and testing should be conducted regarding two emergent findings of this pilot. First, the game allows for both Single Player and Competitive modes. In the Single Player mode, participants play alone and received feedback through the game score. In the Competitive Mode, participants play with a partner and the goal is to score more points than the other player. While the data did not show any significant difference overall between the two game modes there may still be issues with the implementation of a competitive orientation for some types of meditation. Mindfulness-based meditation, for instance, is based on a principle of non-striving [27] and competitive striving has been associated with increases in anxiety rather than reduction [28]. Further research should seek to study this in further depth.

There may also be a possibility of gender-based interaction, particularly with regard to the competitive mode. Previous studies regarding player motivation have shown that female players are less likely than male players to be motivated by competitive in games [30]. While this study did not find any gender differences which met the criteria for statistical significance, there was near significant interaction of gender and trial type in which female players performed better in the competitive condition but male players performed at the same level as they did in the single player condition.

In conclusion, these data offer tangible messages with potential applications for professionals in a variety of disciplines in designing games for mental health more effective for patients suffering from state anxiety, or individuals simply seeking to improve their lives by meditation. When designed and implemented with rigor, games offer an engaging venue for training coping skills using cognitive-behavioral techniques and biofeedback. These techniques can also leverage the motivating aspects of games to introduce mental health skills to populations which might not

otherwise utilize them, such as young men, adolescents, and children [31] and to increase the longevity of the effects of relaxation training in children [32].

Previous studies using biofeedback games to treat anxiety have shown significant improvements for both adolescents [32] and adults [15] suffering from anxiety disorders. However, previous gaming studies have focused largely on biofeedback using heart rate monitors, respiration monitors, and skin conductance sensors. Meditation Deathmatch, and other games like it, may offer a means to integrate the benefits of gaming with current neurofeedback techniques. It is our hope that researchers will take up the challenge of further understanding how cognitive skills influence the efficacy of games for mental health, and how we can optimize them. Such an understanding is likely to improve our ability to advise serious game developers and healthcare providers on how to optimize game-based treatment supplements.

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Author Contributions

Paul Barclay is responsible for the design, coordination, and conduct of this research project. Clint Bowers served as adviser to Mr. Barclay, and provided support in design, analysis, and manuscript writing.

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Competing Interests

The authors have declared that no competing interests exist.

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