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Restortive Effects of Meditation Apps

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RESTORATIVE EFFECTS OF MEDITATION APPS

by

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Abstract

We have investigated two different smartphone meditation apps to determine if they have any effects on stress and check if they are a viable tool that users can engage with to cope with stress during a work break. The dependent variables being measured include affective and cognitive restoration. The control group performed a coloring activity using a mandala figure. The experimental conditions engaged in app guided meditation through either 10% Happier or Calm. Both are health apps that are intended to help users practice a variety of mindfulness meditation exercises and help build healthy habits. This research focused on a specific form of meditation known as mindfulness meditation for gratitude, afterward we analyzed the findings.

Previous workplace mindfulness intervention trials have focused on reducing psychological stress, with limited empirical evidence showing that mindfulness training leads to improvements in the other domains, such as affective and cognitive processes. Research on mobile meditation apps may have been limited by ceiling effects given that previous research did not attempt to induce stress and fatigue prior to intervention. The vigilance task has been used to reduce the occurrence of the ceiling effect, it has the purpose of inducing stress and cognitive fatigue prior to intervention. We ran participants through the experiment then measure and analyze their data to see if stress reduction benefits of mindfulness-based meditation for gratitude can effectively restore stress levels once induced. Benefits associated with meditation include an improved capacity to cope with stressful situations and enhanced attention regulation which are key performance indicators across many domains.

First participants took the Big Five Personality test. Then completed a baseline affective and cognitive assessment (ACA), which included the Positive and Negative Affect Schedule, the shortened version of the Dundee Stress State Questionnaire, and the N-back test. Next, participants completed the vigilance task, followed by another ACA. Participants were then randomly assigned to complete a coloring activity, 10% Happier, or Calm followed by an ACA. Last, participants in the experimental conditions completed the System Usability Scale.

Application: Everyday life involves cognitive demands that can be stressful and decrease performance, especially for workers and college students whose performance is vital within their domains. This research investigates the potential of mindfulness meditation apps' ability to restore cognitive and affective processes once depleted.

Keywords: Mindfulness Meditation Apps, Calm, 10% Happier, Stress, Cognitive Restoration, Vigilance Tasks

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Introduction

In America, there are about 1.5 million non-profit organizations and about 17,205,685 active businesses (Grantspace, 2020; Market Research, 2020). These companies have different values and missions yet face similar human capital barriers that hinder progress towards overall organizational goals. One problem is the proportion of employees who consistently experience high amounts of occupational stress which can become harmful, both psychologically and physiologically. Consequently, companies experience an increase in turnover rates, employee disengagement, and burnout (Maslach & Jackson, 1981). Burnout can be defined as emotional exhaustion, depersonalization, and lack of personal accomplishment, those that are most susceptible to burnout work in service-oriented industries. (Maslach & Jackson, 1981). The burnout process begins with chronic stressors, followed by exhaustion; exhaustion transmutes into depersonalization and/or cynicism. If this state is achieved and not improved, the worker begins to experience feelings of inadequacy (Maslach, Jackson, Leiter, Schaufeli, & Schwab, 1986). The individual may not be aware of their momentum toward burnout and it can take time to brew before the individual becomes aware of their allostatic load (Schaufeli & Enzmann, 1998). The hindrance in performance and mood can have a negative impact on a company's bottom line. Therefore, it would be a wise investment for companies to provide employees with tools that help cope with stress, improve mood, and cognitive performance.

In the United States, 60% of citizens regularly experience stress, including feelings of frustration, anxiety, and fatigue from work along with money-related matters (Anderson et al., 2015; Rau, 2006; Uusitalo et al., 2011). Occupational stress impacts worker productivity, which has been measured from a cognitive performance perspective. Stress is a negative emotional

experience accompanied by predictable biochemical, physiological, cognitive, and behavioral changes that are directed either toward altering the stressful event or accommodating to its effects (Baum, 1990). When individuals first experience stress they may find it feasible to cope until the intensity of stressors exceeds their ability to cope, causing a decrease in task performance (Warm, Parasuraman, & Matthews, 2008). Continued task-induced stress leads to cognitive fatigue (e.g. decay in working memory and weakened control of attention induced by stress; Aaronson et al., 1999; Mueller-Leon-hardt, Stroebaek, & Vogt, 2015; Terte & Stephens, 2014). Cognitive fatigue is the by-product of continuous effortful engagement of directed attention, which has been shown to drain cognitive resources. It is usually affiliated with a state of cognitive weariness and a plunge in motivation (Shen, Barbera, & Shapiro, 2006). Symptoms of cognitive fatigue include self-reported exhaustion and difficulty carrying out mental and physical tasks (Aaronson et al., 1999) as measured by decreases in task performance (e.g. increased time on task, increased number of errors, etc.; Galinsky, Rosa, Warm, & Dember, 1993; Grier et al., 2003).

Many jobs require individuals to maintain sustained attention, alertness, or vigilance for a set duration of time. In the workplace, cognitive fatigue can lead to operational errors that are anti-productive, costly, harmful, or even fatal. Fatigue slows reaction time, the ability to pay attention becomes more challenging, resulting in the possible failure to stick to rules, which have been identified in high profile accidents (Mitler et al., 1988). Pilots fit under the umbrella of occupations that have important duties to fulfill while often being fatigued, do to "unpredictable work hours, long duty periods, circadian disruption, and insufficient sleep" (Caldwell, John, Mallis, & Melissa., 2009, pp. 29-59). An example of how fatigue can affect a situation is the Afriqiyah Airways plane crash that took place in 2010 (Afriqiyah A330 crash, 2013). According

to the incident report, the pilot of Afriqiyah Airways Flight 771 may have depleted his cognitive resources, making it difficult to use these resources when he needed them. His persistence to pay attention to the speed of the plane despite his fatigue may have led him to forget about communicating and attending to other tasks required to keep the plane afloat, contributing to the final accident. In this case, a few minor mistakes turned into a major tragedy, where 104 crew and passengers did not survive the impact. Several plane crashes have occurred due to a pilot's cognitive fatigue, costing the lives of many civilians. Cognitive fatigue has negative consequences in a variety of safety-critical occupations including military and medical contexts. These incidents are preventable and finding a solution can save lives and lower the chance of fatigue-related incidents taking place.

Stress and Health

Chronic stress is a major contributor to psychological distress and physical illness (Kahn & Pearlin, 2006), it has harmful effects on employees and organizational performance. When an employee experiences stress their bodies autonomic defense mechanisms kick in, this is known as General Adaptation Syndrome (Selye, 1950) which consists of three steps. The first response is the alarm reaction which is when the body goes into fight or flight response and experiences an increased cardiovascular output. The second response involves resistance which is when the body tries to endure the presence of the extended stressor to the point of the body releasing stress hormones for an extended time. The third phase is exhaustion which is when the body has been depleted of its resources and can no longer meet the demands to deal with the stress, which can impair the immune system and cause an increased risk of illness and infection. Continuous high

levels of cortisol lead to chronic diseases such as cancer, hypertension, atherosclerosis, diabetes, disorders such as posttraumatic stress syndrome and depression (Pollard, 2002; Pollard 2003)

According to the American Heart Association, cardiovascular disease is a leading cause of death among men and women causing about one in every four deaths in the United States each year which currently estimates about 800,937 people (Mozaffarian et al., 2016). This affects many families as well as the economy. The estimated cost of work-related stress ranges from $221.13 million to $187 billion, health care and medical costs constitute for 10% to 30% of this total (Hassard, J., Teoh, K. R., Visockaite, G., Dewe, P., & Cox, T., 2018). According to positive psychology, there is consistent research that finds power within the concepts of psychological capital which are hope, resilience, optimism, and efficacy within the context of workplace application (Luthans et al, 2008). Therefore, workplaces should consider investing in their employee's psychological capital. Essentially nurturing their psychological capital will mitigate stress, enhance performance, leading to an increase in organizational performance. Research has shown various measures of psychological capital to be positively related to job satisfaction and performance (Youssef & Luthans, 2007) organizational commitment (Luthans et al., 2007), and employee absenteeism (Avey et al., 2006).

Restoration from Stress and Fatigue

Anderson et al. (2015) found that one in five Americans do not participate in activities that reduce or help manage stress. Many Americans do not spend time practicing building healthier mental health routines. For the 4 out of 5 Americans that do participate in activities to reduce stress, most commonly report using stress management techniques such as listening to

music (44%), exercising/walking (43%), watching television for more than two hours per day (40%), and surfing the Internet (38%; Anderson., et al 2015).

There are a variety of ways to reduce stress and enhance one's well-being, and some are more effective than others. For example, spending time in nature yields greater restorative benefits than other types of leisure activities such as sports or entertainment. The stress-reduction effects of nature likely result from the soft (effortless) instead of hard (intense, riveting) fascination that occurs in natural settings, allowing for reflection as well as attentional recovery (Herzog et al. 1997; Kaplan 1995). Annerstedt et al (2013) combined nature and technology. They found that exposure to virtual nature consisting of visual images of a forest and stream, along with sounds of water and birdsong eased recovery from stress. Virtual natural environments represent another way to reduce stress and are readily accessible (McAninch, 2016) and have promising psychological applications (Riva, 2005). Also, research has found that avid video game players show a minor improvement in cognitive functioning and the ability to process information. (e.g. Powers, Brooks, Aldrich, Palladino & Alfieri, 2013). In a study examining the restorative effects of casual video games, researchers found that video games had significant restorative effects on affect but not cognition. They also had an experimental group that participated in guided relaxation meditation, which led to an improvement in cognition but weaker affective restoration. (Rupp, Sweetman, Sosa, Smither, & McConnell, 2017).

The present study focuses on meditation followed by the positive effects that it has on individuals. Rupp et al. (2017) employed a meditative practice called mindfulness, which involves increasing awareness of being in the moment, and thus not worrying about the past or future. Being "mindful" is described as a state in which individuals are paying full attention to the present moment with openness and nonjudgmental acceptance (Kabat-Zinn, 1982). Meta-

analyses have revealed that mindfulness-based psychological interventions decrease stress in healthy nonclinical populations and improve psychosocial outcomes for people with clinical disorders such as anxiety and depression (Bohlmeijer, Prenger, Taal, & Cuijpers, 2010; Chiesa & Serretti, 2009; Hofmann, Sawyer, Witt, & Oh, 2010; Kuyken et al., 2016). When an advanced meditator begins the practice of routine meditation, they are known to establish a hypometabolic state of parasympathetic dominance, which repetitively reduces the rate at which metabolic functioning takes place, even with fluctuating levels of stress. Bringing the meditation to a state of metabolic rest, instead of constant alertness and uncontrollable overreaction in reaction to their environment (Wallace, Benson, & Wilson, 1971). Meditation can be used as a conscious line of defense to help cope with the amount of effort our bodies use to deal with stress during the General Adaptation Syndrome.

Another type of meditative practice is gratitude. Gratitude is a cognitive-affective state usually defined as an individual's tendency to respond with appreciation to the positive aspects of his or her life and may interact with perceived stress and reduce burnout (Chan, 2010; Fagley, 2012; McCullough et al., 2002). When young adults are trained and efficient in practicing gratitude, they gain the ability to use it as a protective mechanism that creates positive perspectives after stressful events (Ng & Wong, 2013; Vieselmeyer et al., 2016). Several recent studies have evaluated and validated the effects of practicing gratitude for a variety of clinically related outcomes. Cheng et al., (2015) administered questionnaires to 525 firefighters, evaluating the effects of gratitude on perceived stress and burnout. High levels of gratitude predicted low levels of perceived stress and burnout, supporting a protective role of gratitude against work-related stress and burnout (Chan, 2010; Cheng et al., 2015; Clark et al., 1988). Firefighters are often in life-threatening situations and are exposed to high-level stressors frequently, and they

were able to effectively use gratitude as a method of protection. Thus, it may be possible that it could be useful for stressors in other occupational settings.

In the workplace mindfulness, meditation may lead to an increased sense of job control by increasing the participants' self-efficacy when handling an overflow of work-related demands (Loucks et al., 2015), which enhances job performance, workplace relationships, and well-being (Good et al., 2016). Individuals who have committed to long-term meditation training have shown improvements in cognitive performance (Cahn & Polich, 2006) and attentional processes (Jha, Krompinger, & Baime, 2007). Similar findings were reported in a study using neuroimaging and an 8-week training course for mindfulness-based stress reduction (MBSR), which heightened activation in executive attention networks and was correlated with improvements in sustained attention and error monitoring (Short et al., 2007).

Technology-Assisted Meditative Practice

As of 2015, 85% of young adults in the United States age 18-29 owned a smartphone. If mental health apps were used to reduce stress and increase well-being, about 56 million young adults would have access to these mental health tools (Smith & Page, 2015). Two studies used smartphone apps to deliver mindfulness interventions to healthy adults. Results included benefits comparable with traditional delivery methods on outcomes of subjective well-being, depressive symptoms, and compassion (Howells, Ivtzan, & Eiroa-Orosa, 2016; Lim, Condon, & DeSteno, 2015). Alternative benefits of providing individuals access to these apps would be impactful beyond the organizational culture, potentially reducing barriers affiliated with regular mental health practices. This brings awareness to mental health in a convenient manner, allowing the

user to choose where and when to use the app in a cost-efficient manner. Thus, these apps have the potential to make an impact on young adult workers and college students. However, there are some limits to these studies that highlight the need for future work and replication. First, these apps only measured affective, but not cognitive, restoration. It remains to be seen if meditation apps can help people achieve cognitive restoration, which was argued above to be important in occupational settings. Second, these studies did not control for the stress and fatigue levels of their participants. Participants were randomly assigned conditions and used the apps during their daily life over several days. A more controlled laboratory study on restoration (e.g. Rupp, et al., 2017) should use a task to induce stress and cognitive fatigue prior to a meditative intervention.

In the proposed study, two mindfulness meditation apps, called Calm and 10% Happier, have been used as meditative interventions, with an active control condition of a coloring activity. An important difference between these apps is that Calm employs elements of nature through its audio and interface. As previously discussed, nature has been shown to be restorative. These interventions will occur following a fatiguing and stressful task.

The following hypotheses will thus be tested:

Hypothesis 1: The vigilance task should cause stress and cognitive fatigue in participants. We will consider this achieved if we observe the following: DSSQ scores should increase, positive affect should decrease, negative affect should increase, and 3-back scores should decrease following the task.

Hypothesis 2: Apps will be effective if: DSSQ scores decrease, positive affect increase, negative affect decreases, and 3-back scores increase following the intervention, and to a greater extent than any restoration observed in the coloring activity control condition.

Hypothesis 3: If nature is restorative then Calm will have greater effects than 10% Happier on the DSSQ, positive affect, negative affect, and 3-back scores.

It should also be noted that experience with meditation, as well as one's personality traits, especially agreeableness and openness, have been reported to moderate the effects of meditative practice (Conklin, et al., 2018). We will measure these traits in participants to test the following hypotheses:

Hypothesis 4: Those who score higher on agreeableness and openness to experience will exhibit greater restoration from the meditation apps.

Finally, we note that a major element in the adoption and use of technology is usability. Technology that is difficult to use or poorly designed is likely to be abandoned (Fogg, 2009; Rupp, Michaelis, McConnell, & Smither, 2018). While some meditation apps have been validated for effectiveness, there are currently no reported usability studies on these apps. Although peripheral to our main goals, we will also test the following hypothesis:

Hypothesis 5: The app that scores higher in subjective usability ratings will also elicit stronger restorative effects.

Method

Participants

The sample consisted of 40 undergraduate students from the University of Central Florida. Participants were recruited through an online recruitment program known as SONA, after completing the study they were granted course credit as compensation. The participants were young adults ranging from 18-23 years old with the average age of. All participants had normal or corrected-to-normal visual acuity and color vision. This research complies with the

American Psychological Association Code of Ethics and has been approved by the Institutional Review Board at the University of Central Florida. Informed consent was obtained from each participant.

Materials

The vigilance task is a computer-based task that is performed on a Dell computer running Windows 7. Participants used overhead headphones and while sitting 66 cm from a Dell E176FP 43.2 cm flat-panel LCD display (1,280 × 1,024-pixel resolution; 60 Hz refresh rate). The display extended under a diagonal visual angle of approximately 14.7 degrees. The testing room was lit up with everyday fluorescent lighting, and the glare on the screen was reduced. Experimental tasks were presented with E-prime v.2.10 (Psychology Software Tools, Pittsburgh, PA; Schnieder, Eschman, & Zuccolotto, 2002).

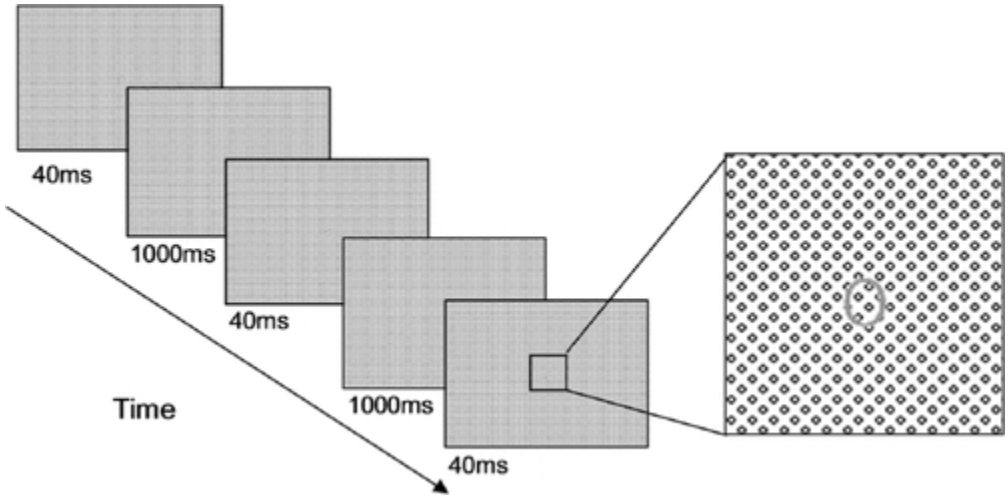

Figure 1: Abbreviated vigilance tasks

The Temple et al. (2000) abbreviated vigilance task was used to induce stress and fatigue. During the task, there were quick flashes of one of two options (letter O) or two false cues

(forward or backward letter D) displayed as 8 × 6 mm light grey capital letters in 24-point Avant Garde font in the middle of the display screen, presented with a visual mask giving the impression that the letter stimuli is actually underneath due to interposition. The mask is a 1mm diameter of outlined grey circles laid out on a blank white background. For every trial, the probability of target signal trials was .20, and the probability of non-target stimulus was .80. Each stimulus appeared for 40 milliseconds, with an inter-stimulus interval of 1000 milliseconds. Throughout the exercise, participants were briefed to fixate the middle of the screen for the target stimulus and push the space bar on the computer when a target appeared and to not respond to non-target stimuli.

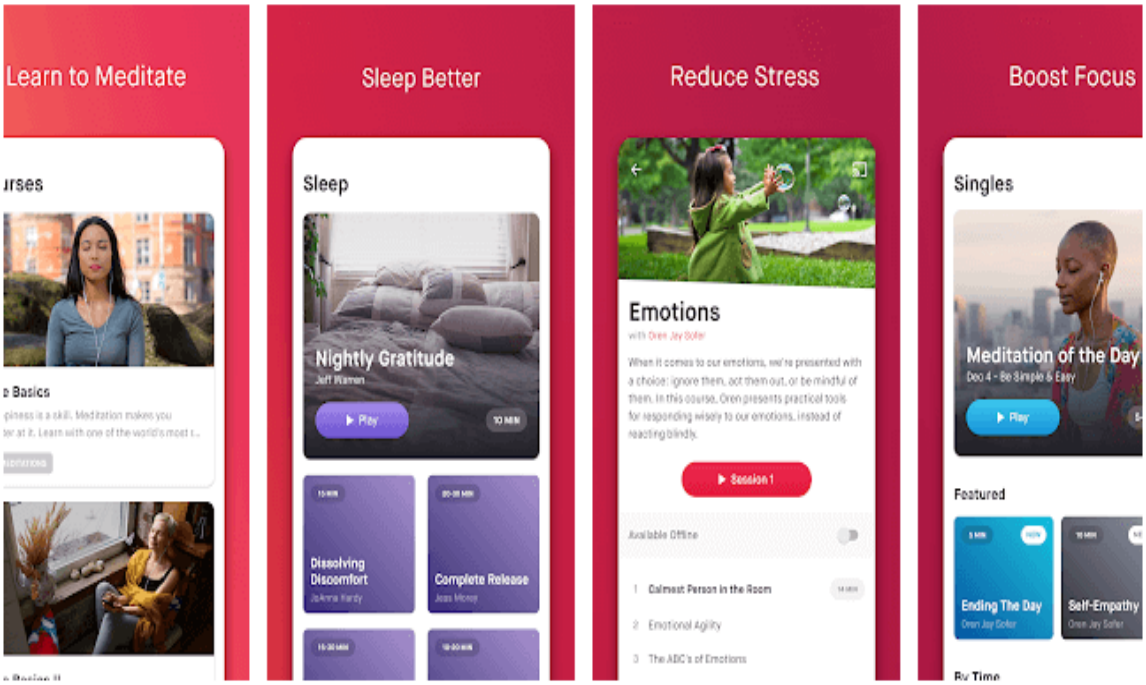

Figure 2: 10% Happier Interface

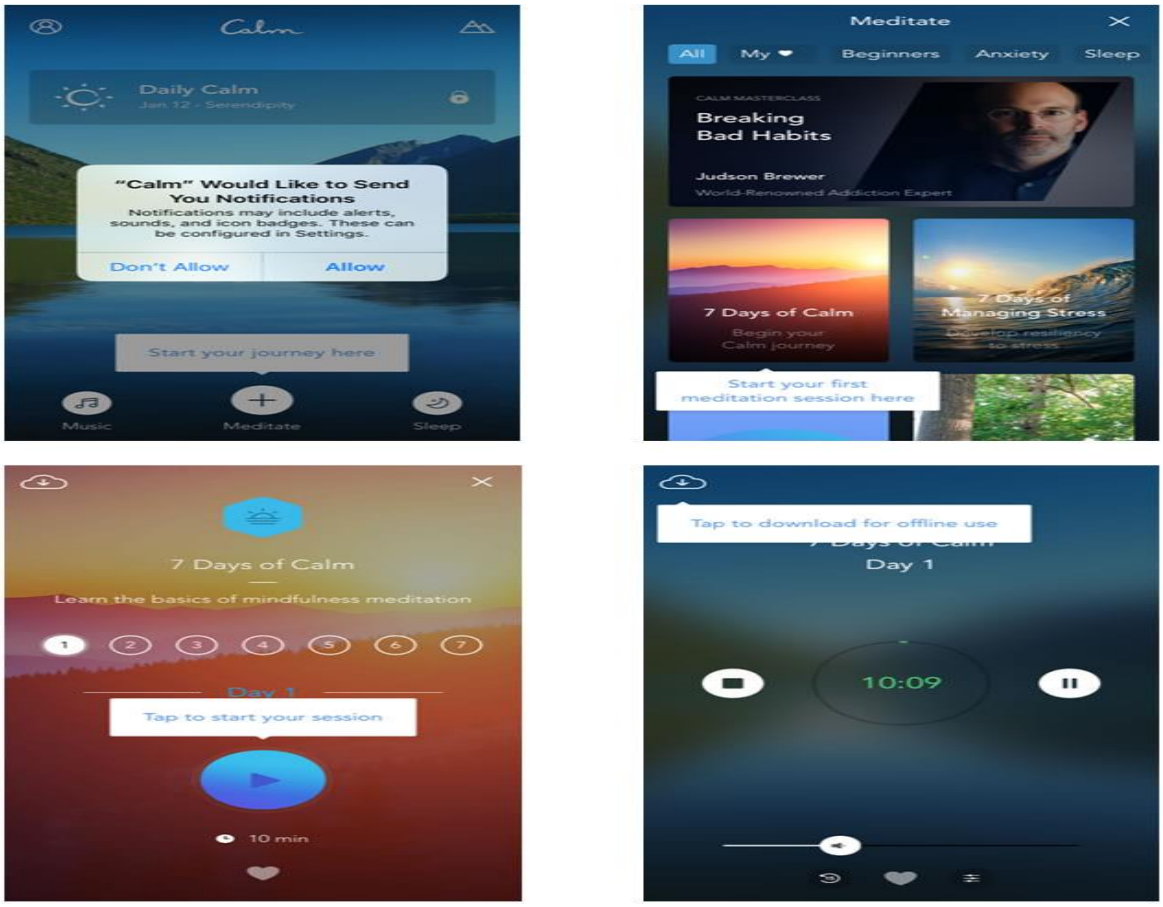

Figure 3: Calm Interface

The meditation apps Calm and 10% Happier will be installed on an android device and used as a meditational guide for the intervention. First, participants will take a seat on a cushion. Then they will have an unlocked android laid in front of them. Then they will be given a piece of paper with directions suited for each app. The directions for Calm will tell participants to first find the app and open it. Then go to the meditation bubble and click on "7 days of Happiness ". Now click on "Practice Gratitude" narrated by Tamara Levitt, which will begin their guided meditation session. For 10% happier the directions will tell them to first find the app and open it. Once open click singles which will have an icon with 4 squares. Now click on the meditation

labeled “Interconnection + Gratitude narrated by Jeff Warren and then click play. Both serve the purpose of teaching beginners how to meditate and applying those skills to their life. They offer guided meditations that aim to help regulate stress, overcome sleep issues, along with many other features.

Measures

The Big Five Inventory is made of five personality factors, which contain a sum of 44 items (John et al., 1991). We only measured the traits of agreeableness (9 items, e.g., “I see myself as someone who likes to cooperate with others”), and openness to experience (10 items, e.g., “I see myself as someone who is inventive”). Each question was appraised on a 5-point Likert scale, spanning from “Strongly Disagree” to “Strongly Agree”.

An Affective and Cognitive Assessment (ACA) was used to measure stress reduction and cognitive restoration. This included the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1998), the measures abbreviated, 20-question version of the Dundee Stress State Questionnaire (DSSQ-S; Matthews, Emo, & Funke, 2005; Matthews, Joyner, Gilliland, Huggins, &, Falconer, 1999) which measured three components of task-induced stress, those being task engagement, distress, and worry. The ACA also includes the 3-back version of the N-back task, which is a measure of working memory capacity and attentional control (Kane, Conway, Miura, & Colflesh, 2007). (need additional detail regarding 3 back tasks)

The System Usability Scale (SUS; Brooke, 1996) was used to measure the perceived usability of the two apps. This scale is made of 10 questions created to measure users’ perception of usability on a software system, then evaluated on a 5-point Likert-type scale. The two major testing domains will be classified as Usable (8 items), and *Learnable* (2 items).

Procedure

The independent variable of interest was the type of intervention applied after the vigilance task. Participants engaged in the guided mindfulness meditation, using one of the apps or a coloring activity control. The interventions lasted for a duration of 15-minute each, afterward; participants completed surveys. The app interventions consisted of audio recordings that instructed participants through mindfulness meditation.

To begin, participants provided consent and filled-out demographic surveys measuring the history of meditative practice. Next, they were directed to take a seat at the computer. Then, they filled out baseline (pre-vigil) ACA measures (PANAS, DSSQ-S, and 3-back). Participants were provided with a pen and paper for this scale, then informed to score how they feel at the beginning of the experiment using PANAS and DSSQ-S at baseline. Next, participants engaged in the vigilance task. Participants first completed a 5-minute practice trial, afterward they received informative feedback to become competent with the vigilance task. This task has no set amount of hit or false alarms that participants must achieve to continue with the study. After the practice trial, participants completed six continuous 2.5-minute periods of the tasks devoid of feedback. Each continuous period of engagement with vigilance tasks consisted of 120 trials and the target to signal trials were proportionate with the non-target trials between periods.
After the vigilance tasks, participants transitioned directly into the post-vigil ACA, which was proceeded by random assignment to one of the three test groups. For both experimental groups, participants were given a brief overview of guided mindfulness meditation after completion of the vigilance task. After the intervention, participants accomplished a post-intervention ACA. For those in either of the app conditions, they concluded the study by completing the SUS.

Results

For the following analysis, one-way ANOVAs were used to examine differences between each condition. Participants' scores on each component of the ACA were modified into standardized change z scores (Post-Pre/σ_{Pre}). The pre-vigil scores represented the pre-condition for the post-vigil scores, and the post-vigil scores represented the pre-condition for the post-intervention scores. Each ACA component was tracked to determine whether there were any significant changes from pre- to post vigil or from post-vigil to post-intervention, then we examined 95% confidence intervals of the standardized change scores. In conditions where the error bars do not overlap zero, we consider this an indication of a significant non-zero change.

Post-Vigilance Results of the ACA

We conducted one-way ANOVAs after the vigilance tasks to examine if there were effects of the vigilance task on cognition, as well as differences between groups on target accuracy on the 3-back task. Group differences are not expected following the vigilance task, as the participants had yet to experience an intervention and all were treated equally up until this point in the experimental procedure. No significant effects were found which is reflected in the mean change scores for target accuracy as post-vigilance reveals (Color M = .18, SD = .58), (Calm M = -0.11, SD = .17), & (Ten Percent M = -0.10, SD = .13). Although the color group displayed an increase in target accuracy after the vigilance tasks unlike Calm and Ten Percent, the difference was not significant as shown in the one-way ANOVA ($F(1,39) = 2.72$, $p = .08$, $\eta 2 = .13$). Observation of the 95% confidence intervals suggest that no change scores were

significantly different from 0. This suggests that the vigilance task did not alter participants' accuracy on the 3-back task.

In terms of target RT on the 3-back task, the coloring group score looks different but between interventions the mean change scores for target reaction time were not significant (Color M = .18, SD = .81), (Calm M = -0.18. SD = .16), & (Ten Percent M = -.19, SD = .13. Results show that post-vigilance group differences were not significant ($F(1,39) = 2.27$, $p = .12$, $\eta 2 = .11$). Again, the 95% confidence intervals all overlap 0, suggesting that the vigilance task did not change reaction time on the 3-back task.

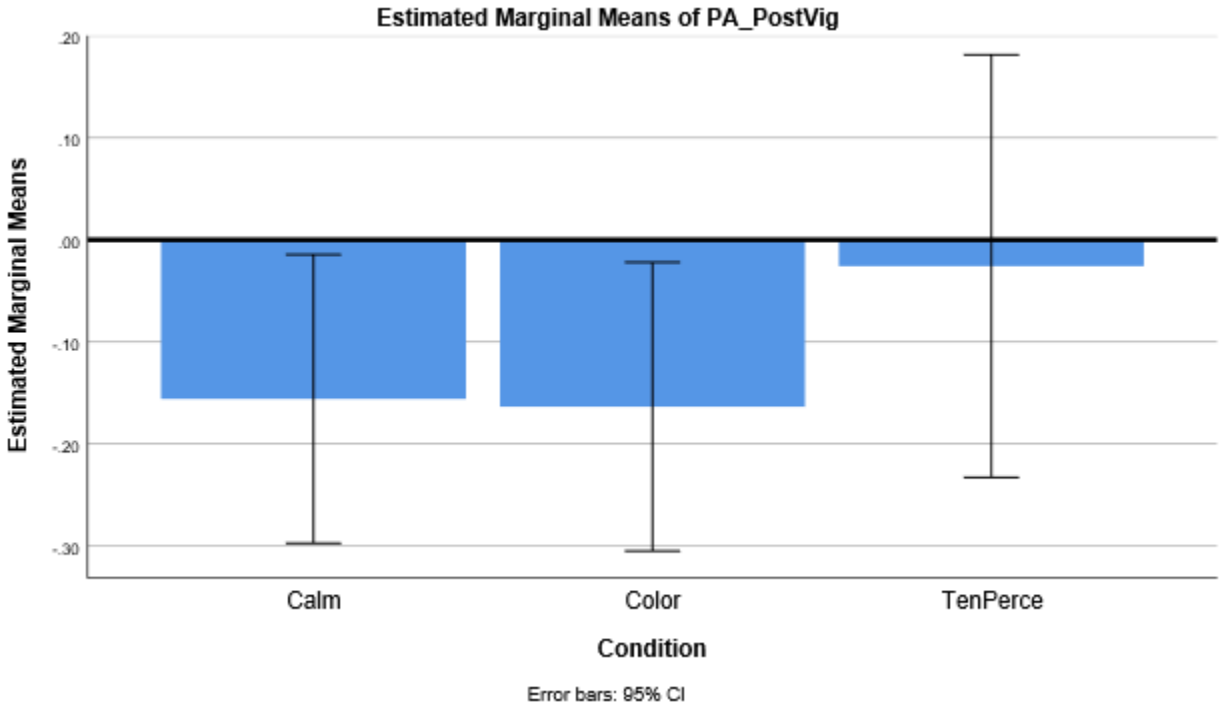

Figure 4: Positive Affect Post-Vigilance Tasks

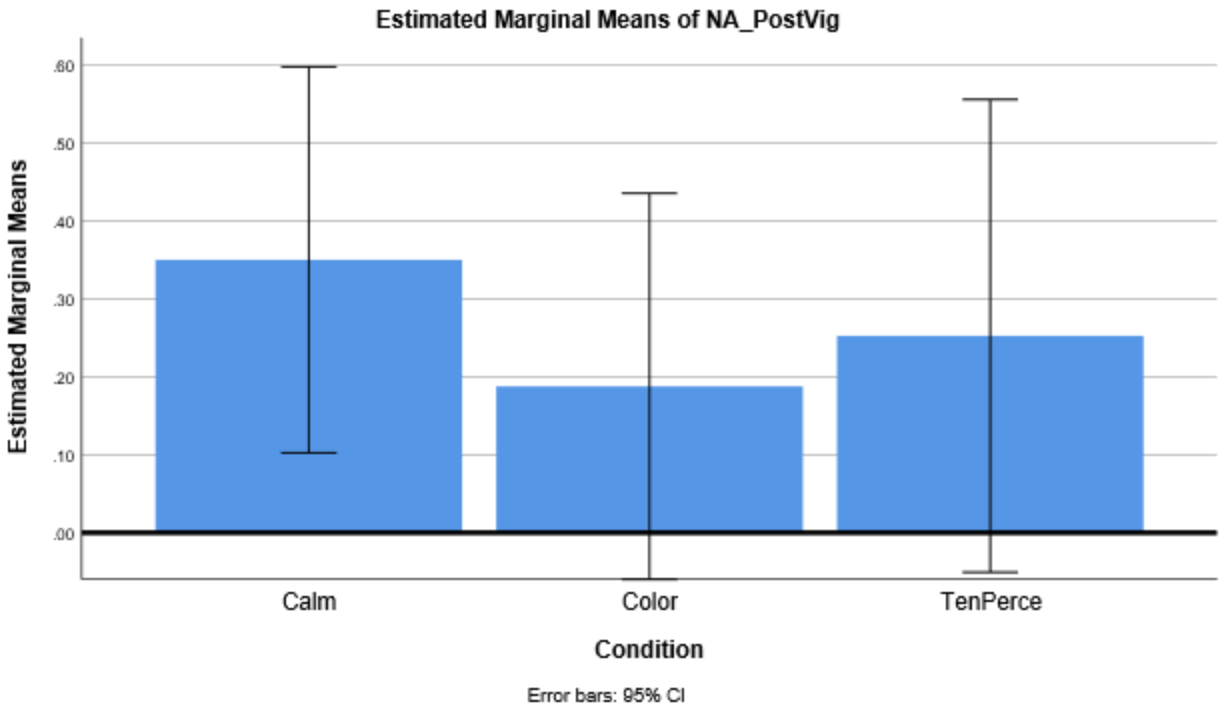

Figure 5: Negative Affect Post-Vigilance Tasks

Next, we examine the affective components of the ACA. Based on the average change scores collapsing across the groups, there was a significant decline in positive affect (M= -.13). As expected, a one-way ANOVA showed no significant difference between the groups, [F(2,35) = .70, p = .50, η2 = .04]. There was an increase in negative affect for all groups (M= .26). Again the one-way ANOVA indicated no group differences [F(2,38) = .45, p = .64, η2 = .02].

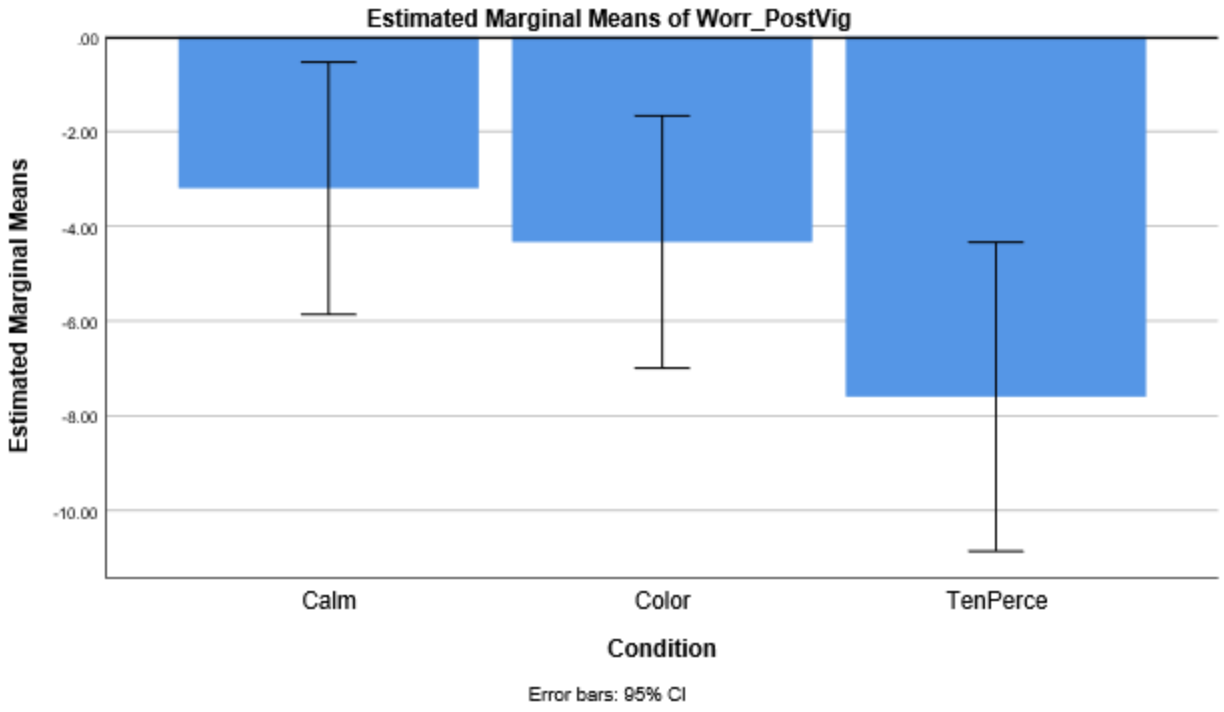

Figure 6: Worry Post-Vigilance Tasks

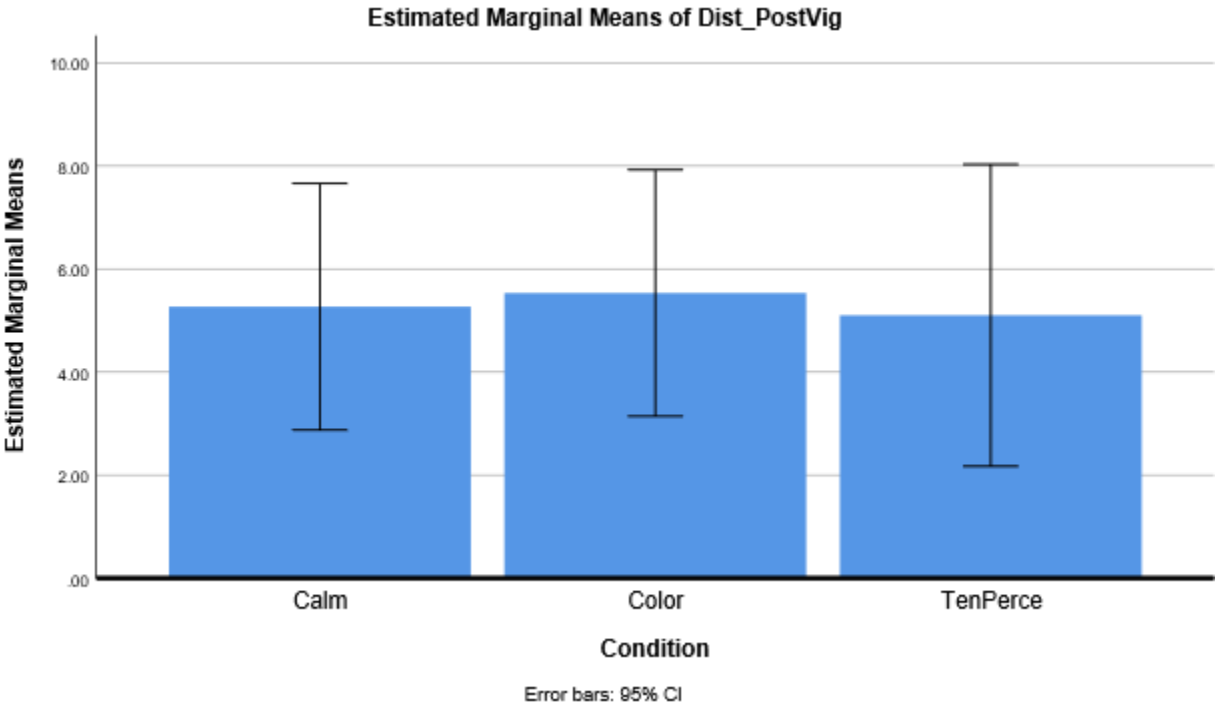

Figure 7: Distress Post-Vigilance Tasks

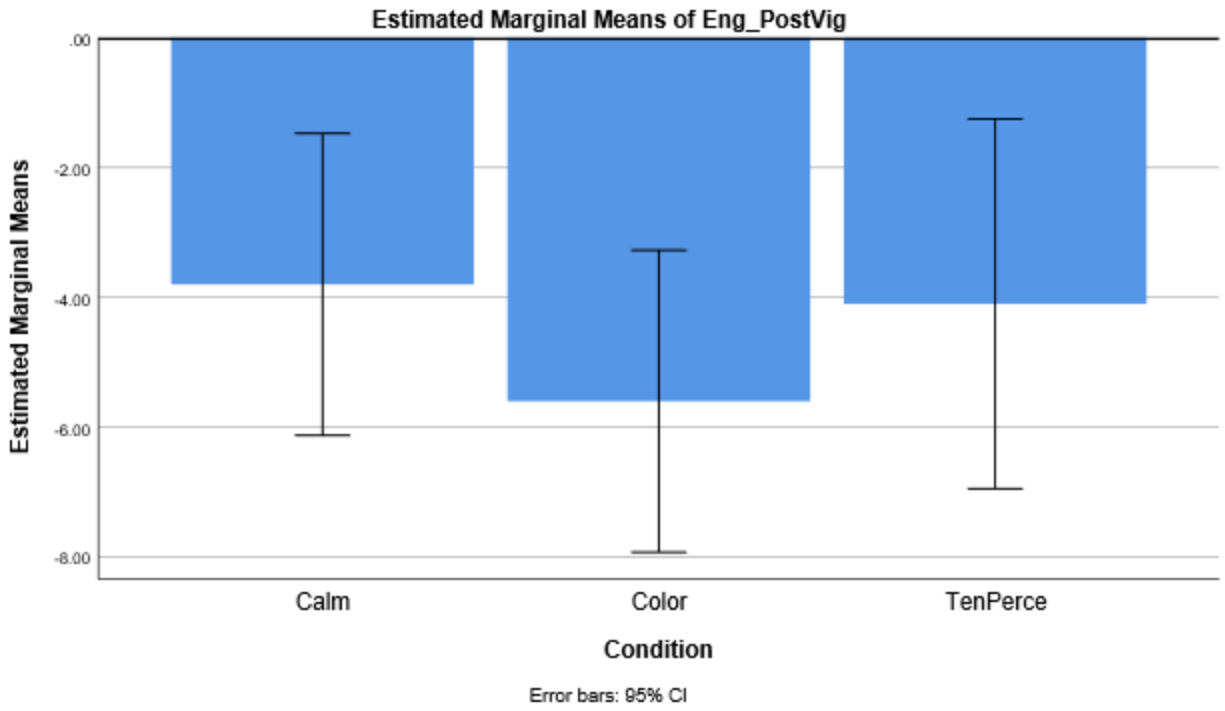

Figure 8: Engagement Post-Vigilance Tasks

For the DSSQ-S scale, there was a decrease in worry (M= -4.73), an increase in distress (M = 5.33), and a small decline in engagement (M = -.46). As expected, there were noa significant group differences on worry [F(2,38) = 2.31, p = .11, η2 = .11], distress [F(2,38) = .03, p = .97, η2 = .002], nor engagement [F(2,38) = 0.68, p = 0.51, η2 = .036]. These results are compatible with prior vigilance research which reveals an increase in stress and negative emotions following the vigil but are inconsistent with prior work suggesting cognitive declines following the vigil.

Post-Intervention ACA

Next, we conducted one-way ANOVAs on target accuracy post-intervention scores. Calm participants had a considerable increase in target accuracy compared the other conditions. As

displayed in Figure 4, the target accuracy for Calm (M = .21, SD = .57) was the only condition where the 95% confidence interval showing an increase in target accuracy was significantly greater than 0, unlike Color (M = .08, SD = .31) and Ten Percent (M = -.06, SD = .14). However, the one-way ANOVA on target accuracy showed no significant differences between the groups $F(1,39) = 2.72$, $p = .08$, $\eta 2 = .13$. Further, there were no significant changes in reaction time post-intervention scores. Between interventions the mean change scores for Color (M = -.08, SD = .13), Calm (M = -.04, SD = .20), and Ten Percent (M = .02, SD = .17) were not significantly different F(1,40) = .99, p = .38, η2 = .05. The 95% confident interval error bars do not overlap 0, therefore, none of the reaction time scores significantly changed post-intervention.

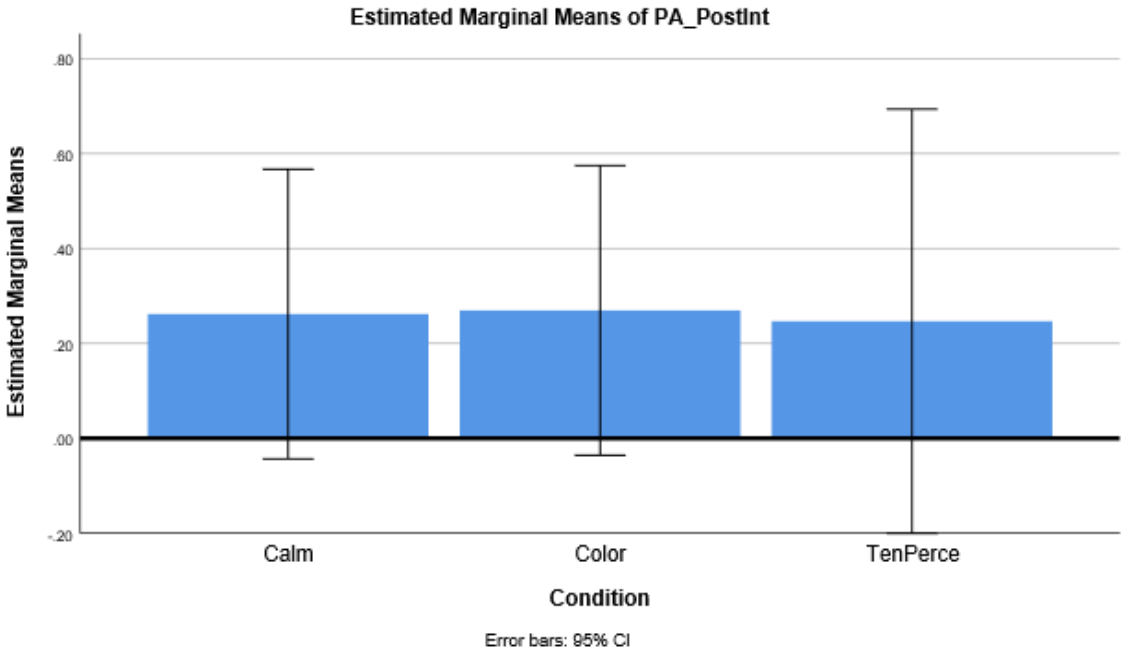

Figure 9: Positive Affect Post-Intervention

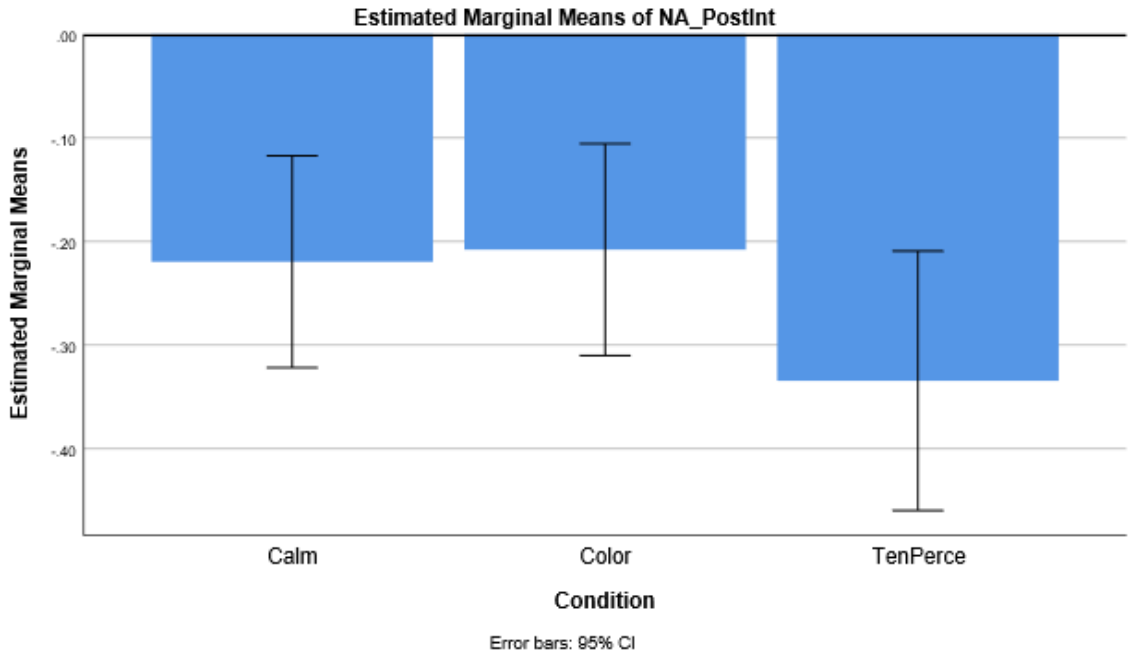

Figure 10: Negative Affect Post-Intervention

The intervention increased positive affect for conditions (Color M= .26, Color M = .27, Ten Percent M = .25), although observation of confidence intervals reveals these changes did not significantly differ from 0. Further, the one-way ANOVA revealed no significant group difference [$F(2,35) = .004$, $p = .99$, $\eta 2 = .00$]. Similar, there was a decrease in negative affect (Color M = -.21, Calm M = -.22, Ten Percent M= -.33]) and all confidence intervals did not overlap 0, suggesting significance. Again there were no group differences [$F(2,38) = 1.45$, $p = .25$, $\eta 2 = .07$].

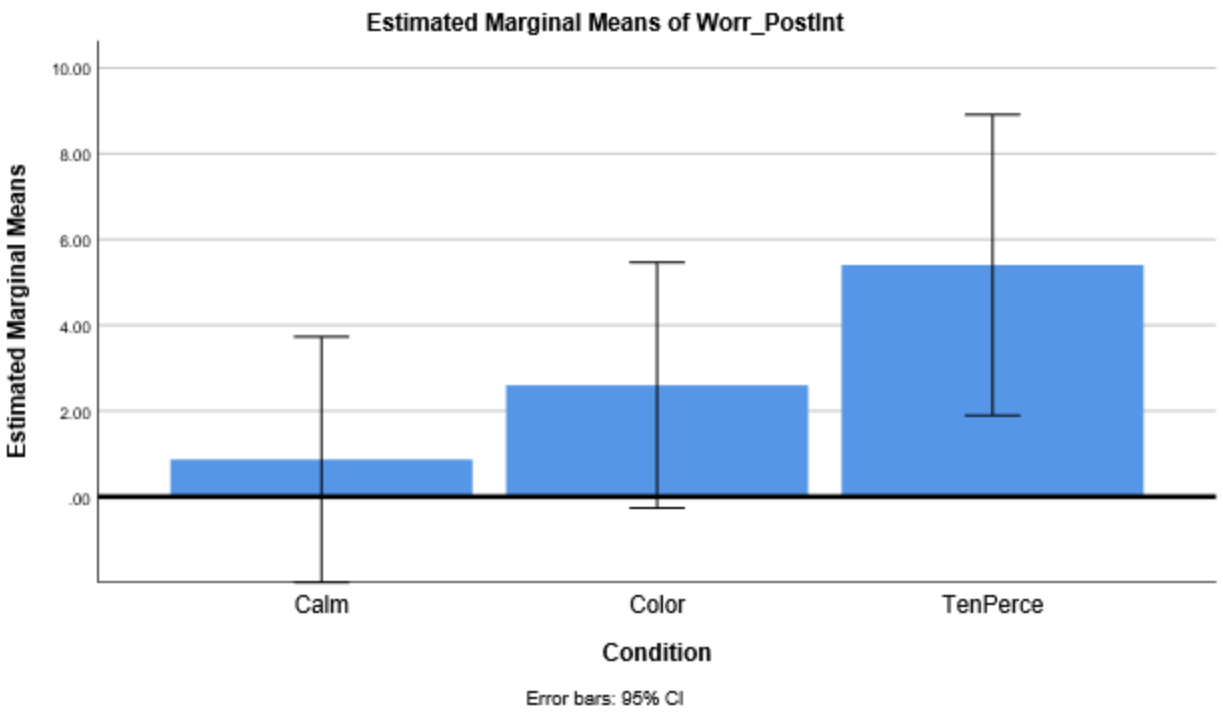

Figure 11: Worry Post-Intervention

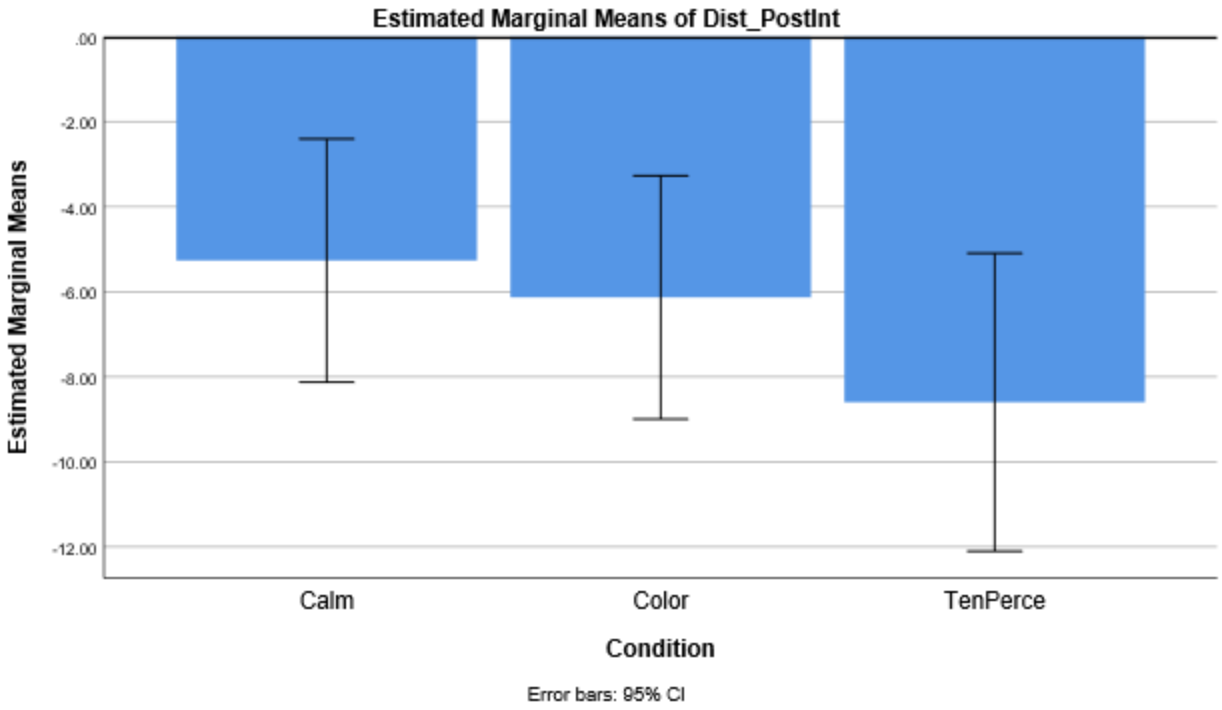

Figure 12: Distress Post-Intervention

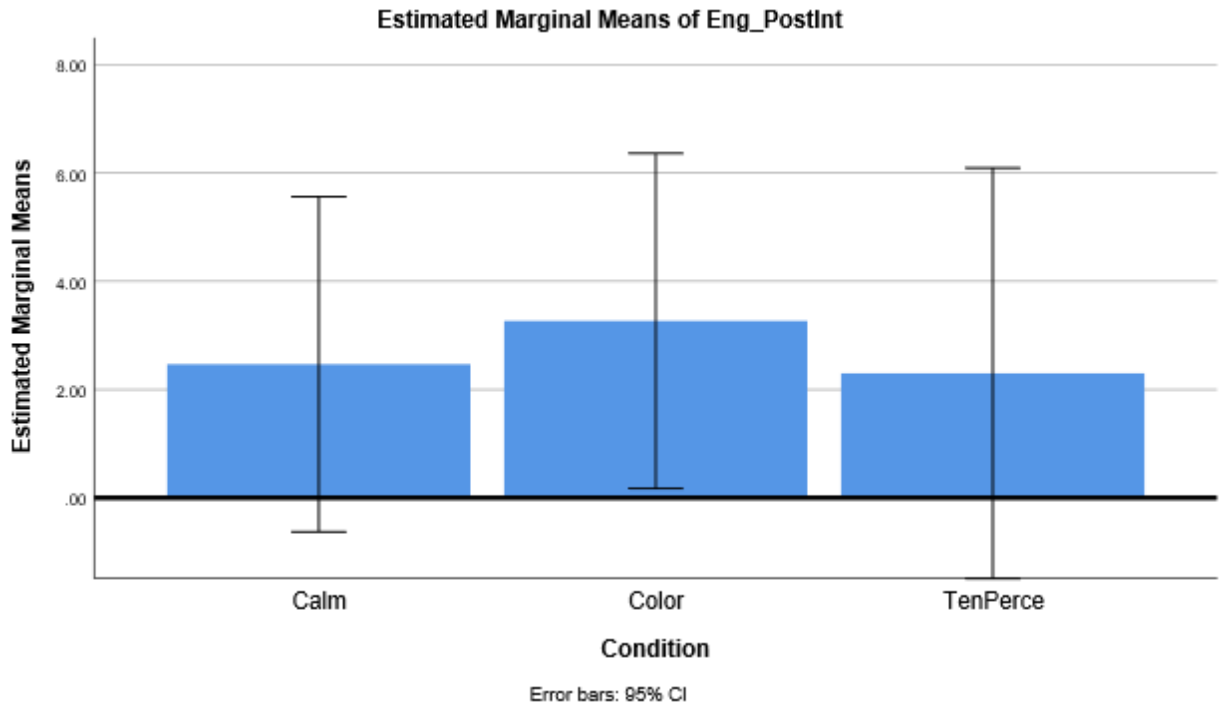

Figure 13: Engagement Post-Intervention

For the DSSQ-S scale, there was a increase in worry for all groups (Color M = 2.6, Calm = .87, Ten Percent M= 5.4), with confidence intervals indicating significance from 0 only for the Ten Percent condition. There were no significant group differences, [F(2,38) = 2.06, p = .14, η2 = .10]. Following intervention there was a decrease in distress for all groups (Color M = -6.1, Calm M = -5.3, Ten Percent M = -8.6), with confidence intervals indicating significant change from 0. There were no group differences in distress [F(2,38) = 1.15, p = .33, η2 = .06]. Last, all groups increased in engagement (Color M = 3.3, Calm M = 2.5, Ten Percent M = 2.3). Confidence intervals showed that only the Color group resulted in change scores significantly larger than 0. Again, there were no group differences in engagement [F(2,38) = .10 , p = .90, η2 = .01]. These results are compatible with prior research which reveals a decrease in stress and negative emotions following a break but is unique in showing such effects for the apps.

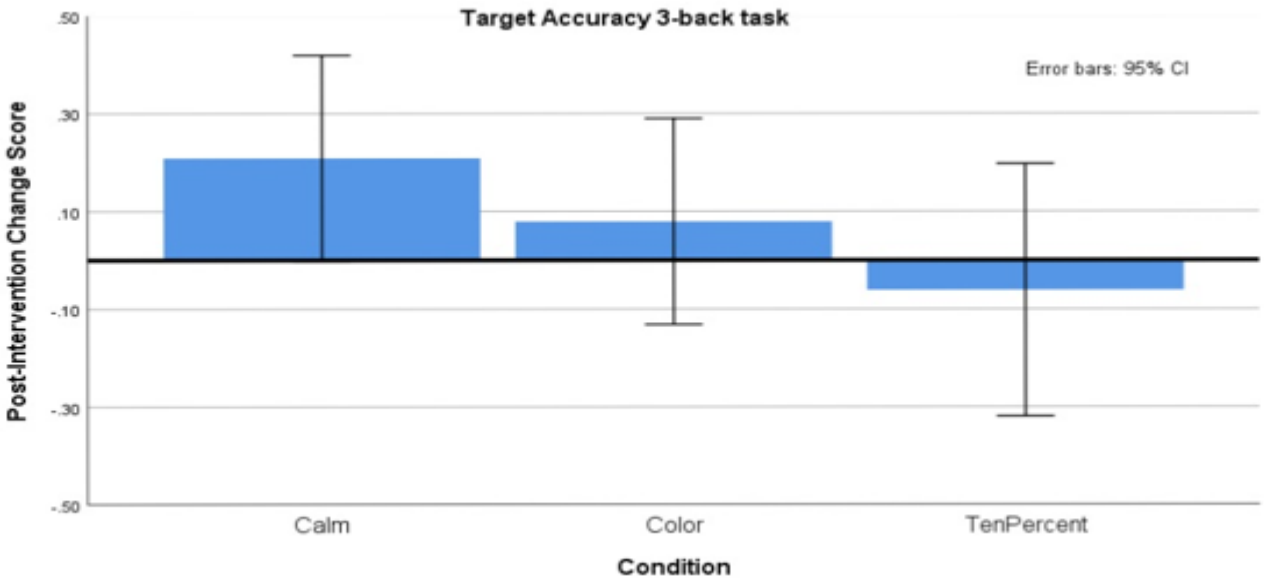

Figure 14: Post- Intervention Targeted Accuracy 3-back Tasks

We conducted correlations to analyze the Big-5 traits which were evaluated as potential covariates to explain the effects of the interventions. Two significant correlations with dependent variables were found. Agreeableness correlated to an increase in post-intervention worry $r(38) = .309$, $p < .05$ and a decrease in post-intervention stress $r(38) = .26$, $p < .05$

We conducted an independent groups t-test on the system usability scale, and found that the usability score for Calm (M = 40.33, SD = 6.23) was slightly higher than Ten Percent (M = 38.90, SD = 4.82) but the difference between the apps was not significant $t(23) = .45$, $p = 51$. On a usability scale they would both score a 4/5.

Discussion

Interpretations

Post-vigilance tasks did not cause any significant changes in 3-back performance but post-vigilance results for ACA are compatible with prior vigilance findings. On the DSSQ-S participants reported an increase in distress than a decline in worry and engagement. PANAS participants reported an increase and negative emotions, and a decrease in positive emotions, therefore the task was effective. We speculate this must be due to the repetitive cue for the participant to respond continuously for 15-minutes. Post-intervention scores for the group using Calm had a notable increase in target accuracy, this app differentiates itself from Ten percent and the Coloring group. It has on-going nature scenes displayed on the interface as well as nature sounds in the background that play throughout the meditation session. The role of nature may have played a role in increased target accuracy. This correlates with the nature restoration theory (Kaplan, 1995), which states that the ability to concentrate is restored by exposure to nature-

related environments. We found that all groups experienced an increase in cognitive performance, but these effects were limited since most of the participants were first-time meditators.

Post-intervention results for ACA reveal that all of the interventions increased affect, but the change was not significant with the exception of worry on the DSSQ-S. What caused the increase in worry is unknown. However, distress was reduced, and engagement was increased. PANAS participants showed an increase in positive emotions and a decrease in negative ones. We see that the apps can increase affect, which may be an indicator that apps do have the potential to significantly improve affect, but more research is needed to get a better understanding.

Individuals that scored higher in agreeableness had lower chances of being distressed after the intervention. Those higher in agreeableness may have been more comfortable allowing the speaker to guide them through the meditation. No other personality trait predicted participants' responses to the interventions, therefore no other ACA measures are influenced by an individual's personality traits.

A well-designed mobile app will be easy to use, efficient, and useful in helping the user achieve their goal (Van Welie et al., 1999). Calm had a higher usability score and a greater increase in cognitive performance then Ten percent, but the results were not significant. On a usability scale, they both scored 80%. A high usability score heightens the chance for a user to trust the product, which has been shown in previous research (Atwater et al., 2015). Both apps

were easy to use, displayed information in a comfortable manner, and helped the users achieve their goals with a low amount of cognitive burden.

Findings reveal that neither Calm or Ten Percent is better or worst then the other. They both improved cognitive performance and affect and had similar scores on the usability scale.

Limitations:

The results of our study can only be applied to first-time meditators. Thus, these findings are not generalizable to higher-level meditators being that experience creates stronger effects. In our study we did not control for experienced meditators, therefore, our study couldn't fully demonstrate the apps effect vs. the mandala. But being that first-time users of these app show an improvement, it is fair to speculate that long-term use might lead to even better benefits.

We also acknowledge that our lab environment may not emulate a real work environment. In the overall research design, there were a few events that may have skewed results. While we did provide participants' headphones, they were not strong enough to block out the noise happening outside of the lab. In this instance, we suggest noise cancellation headphones to researchers that may run a similar study. In a meditation session or exercise that demands one's attention, any interference can contaminate the final result. Secondly, we did not have participants report their user experience on paper. Therefore, we were unable to track their history and familiarity with meditation, which would have allowed us to run a group comparison. Then analyze the difference in outcomes, while considering their meditation experience.

For the 3-back tasks, participants improved their scores each time, even after being stressed out by the vigilance tasks. It is possible that the participants became familiar with the 3-back through repetition and began to do better because of this. To find clarity, it would be helpful to tests the validity of the 3-back. This could be done by running participants through an experiment where they alternate between 3-back tasks and vigilance tasks, and track if participants still improve each time they partake in the tasks. The information could decipher if the results founded are supported or call into question the reliability of the 3-back tasks.

Last, we should acknowledge that although both groups did meditate on gratitude, they were led by two different meditators, that used different topics to express gratitude through meditation. One's subjective experience within this meditation could affect the outcome that it had on that individual. Also keep in mind that one meditation session, may not represent the effectiveness of the app as a collective tool. This is a platform with an array of options, testing several meditation sessions within both and then summarizing the results may help increase accuracy in deciding which app is better. That being said this is one study, and more research is needed to test the capabilities of these apps.

Conclusion

We dedicate our findings to the subject of app validity and effective work breaks; this is an area that is new and young in the world of research. Health apps will become a concentrated area of research, they serve as health and wellness tools in which users have direct access. Technological advancement is an ever-evolving function of our society and health apps will play a role in solving many issues, testing the validity of these apps is important as there are many people that use them to help achieve goals such as changing long-term behaviors. For employees, these apps also have the potential to increase cognitive performance and improve the mood of workers. Businesses may offer these tools as a source of coping but should be wary of relying on them.

While previous research on effective work breaks has not induced stress before an intervention, that is a factor we took into consideration. Our findings back that meditation apps can be an effective and relaxing method to recover from cognitive and affective fatigue, but more research is needed to test if this restoration is significant. It is also important to note that there are different avenues that one can use to obtain cognitive and effective restoration, and this will vary depending on the individual.

Future research should study what would happen if we ran the experiment on meditators with high experience. Since they are more likely to reap the benefits of being a long-term and consistent meditators (Short et al., 2007).

Finally, because we were not able to obtain a broad sample across racial and cultural groups, future research should focus on the user experience and effectiveness of these apps. The benefits of meditation apps may vary amongst different groups of people, leading to variations of

app effectiveness. Forthcoming research should analyze what factors can be adjusted that can improve effectiveness across different groups.

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Appendix A – Figures

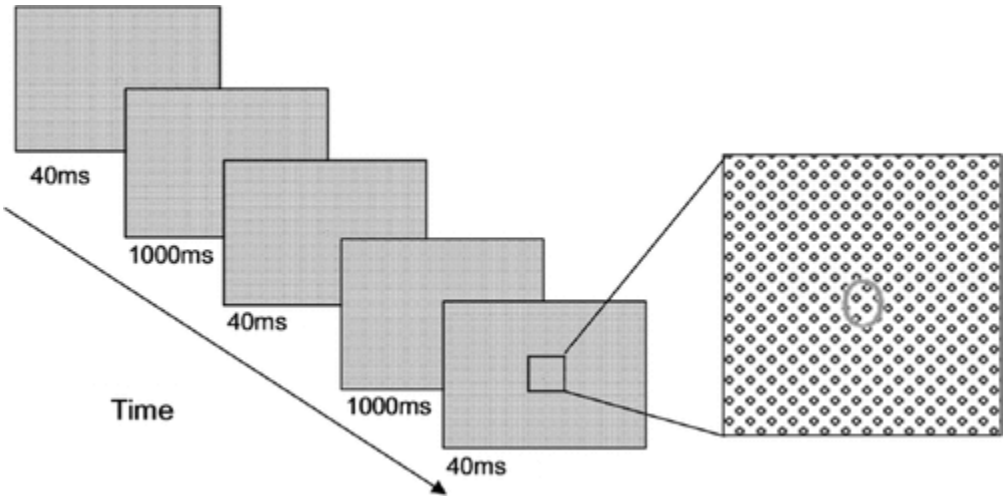

Figure 1: Abbreviated vigilance tasks

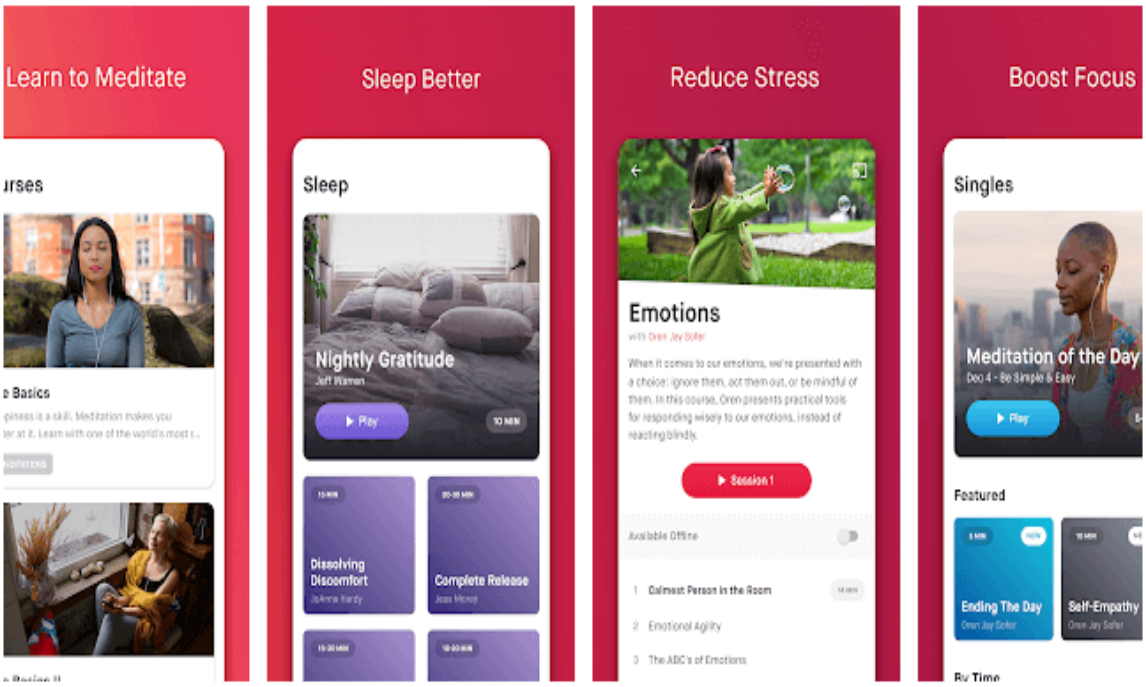

Figure 2: 10% Happier Interface

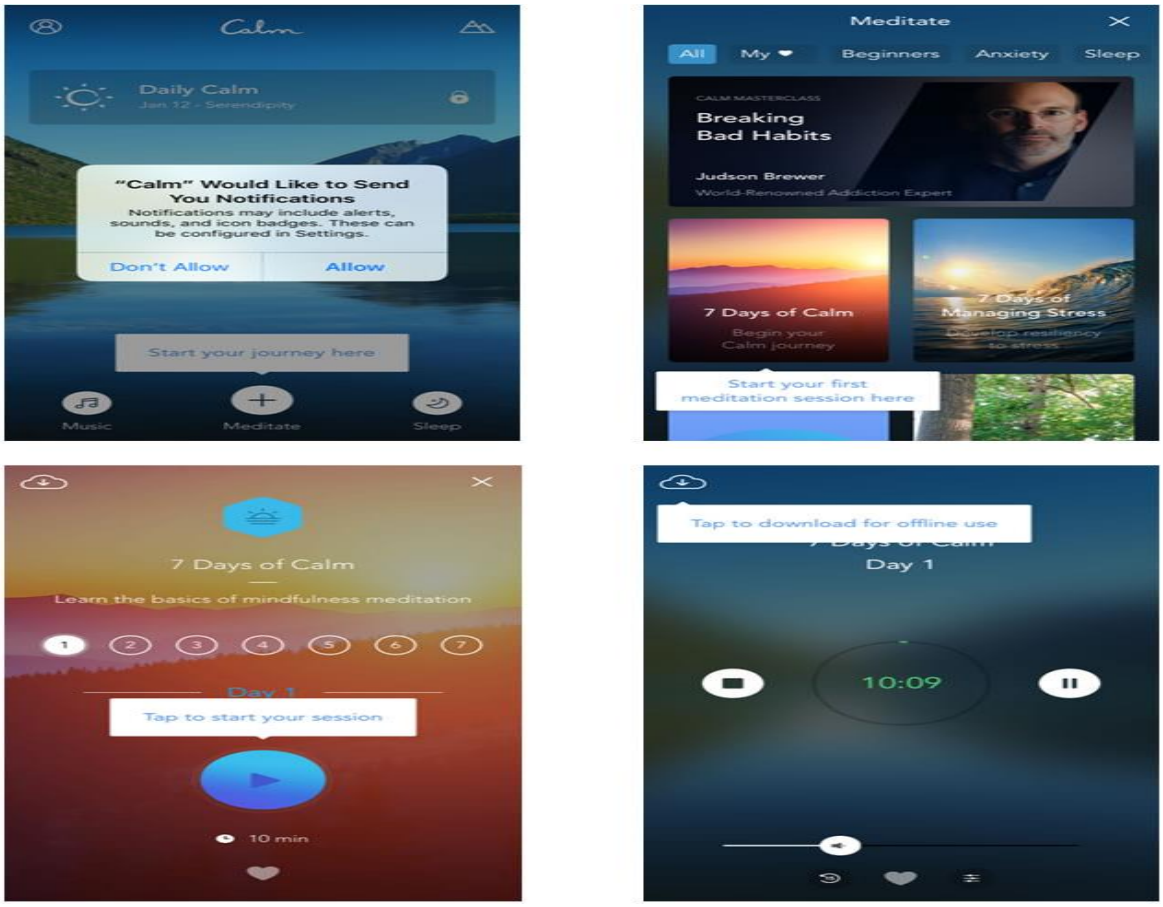

Figure 3: Calm Interface

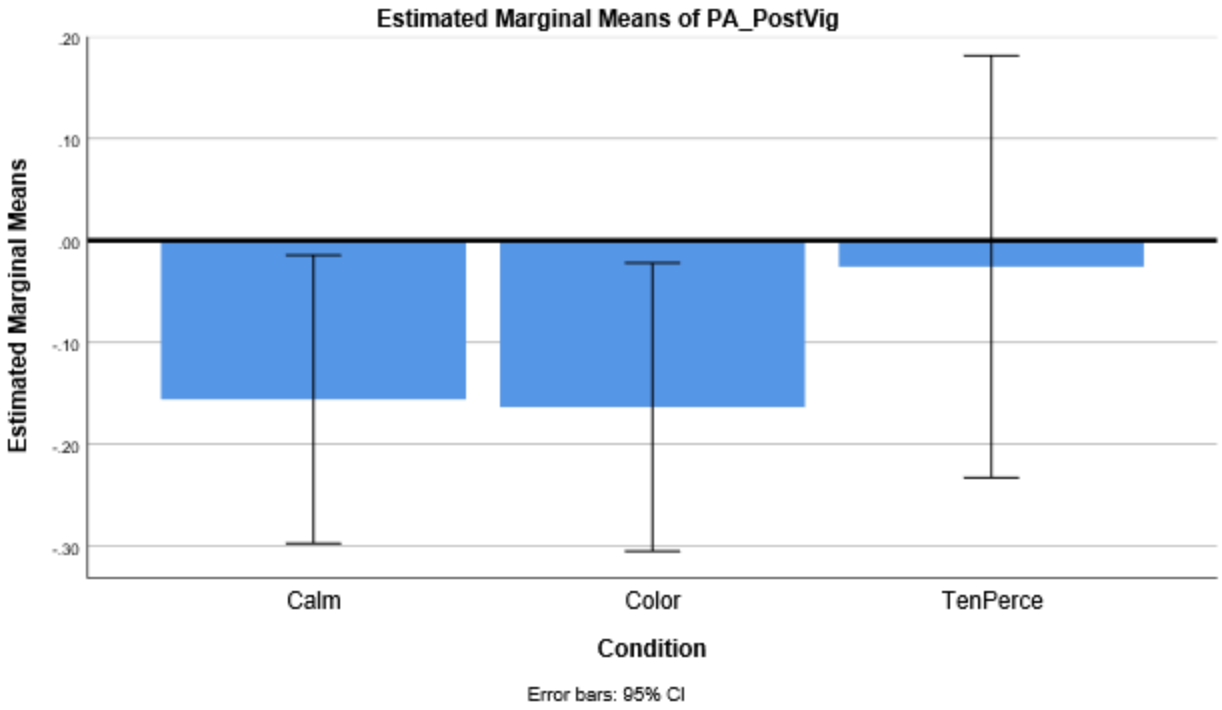

Figure 4: Positive Affect Post-Vigilance Tasks

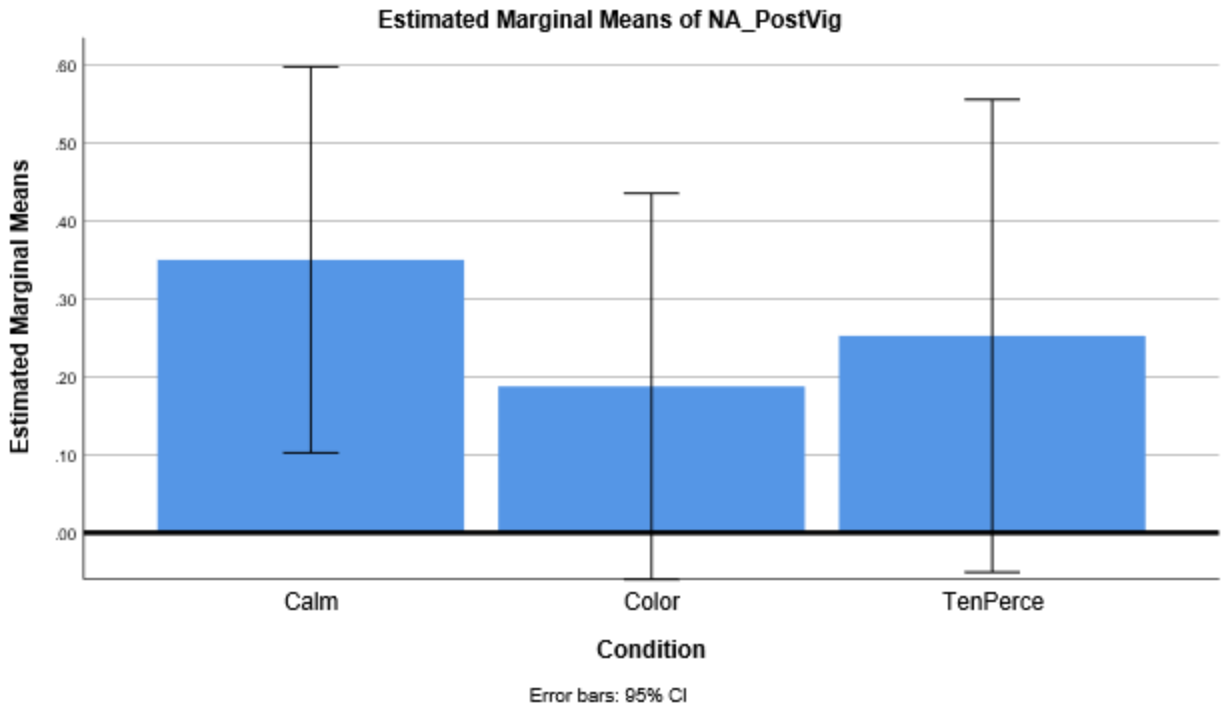

Figure 5: Negative Affect Post-Vigilance Tasks

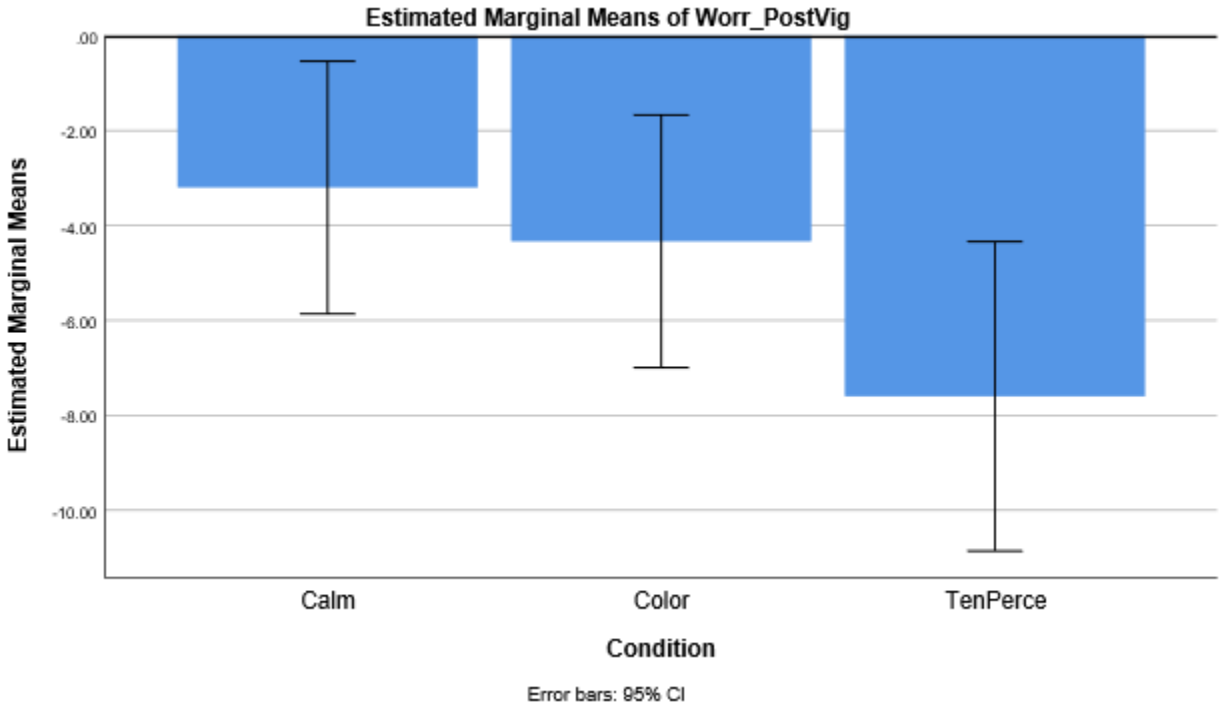

Figure 6: Worry Post-Vigilance Tasks

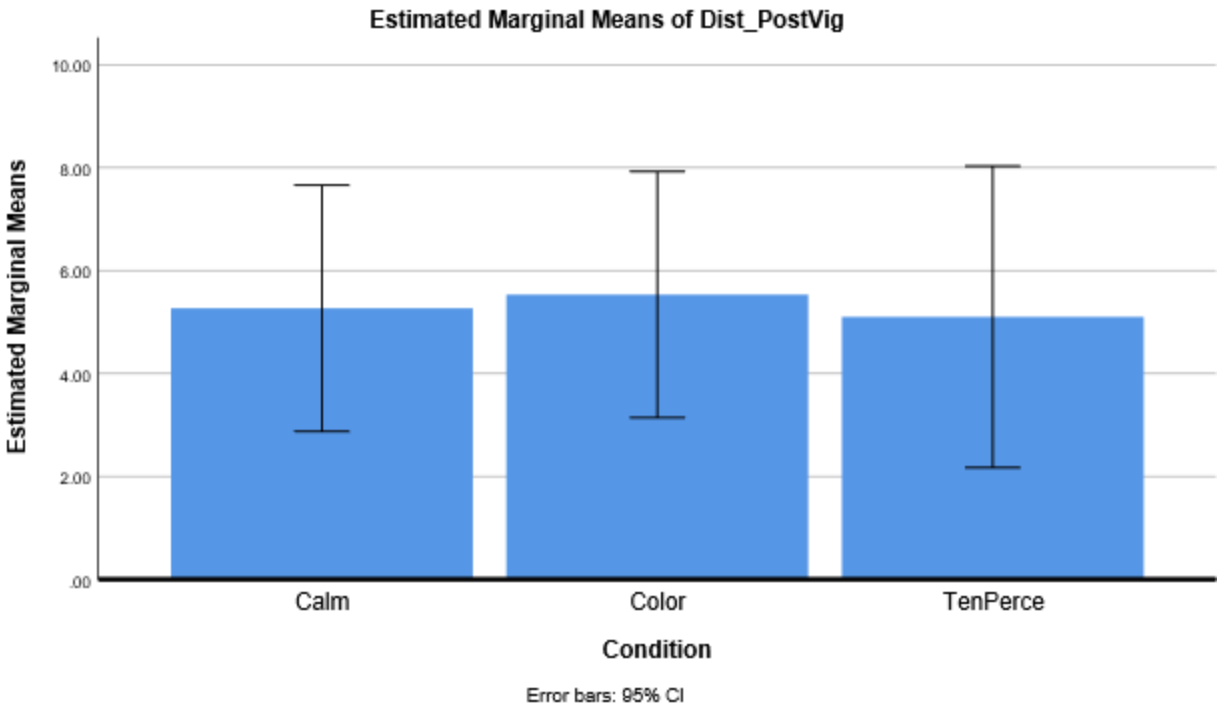

Figure 7: Distress Post-Vigilance Tasks

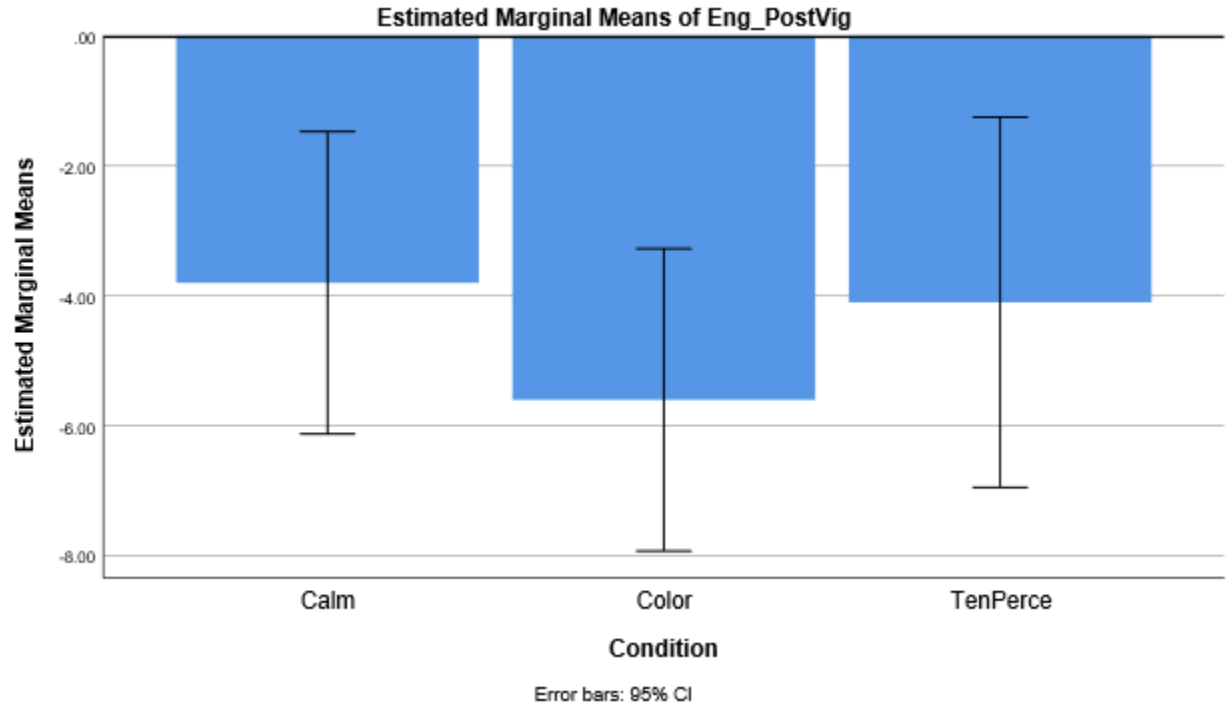

Figure 8: Engagement Post-Vigilance Tasks

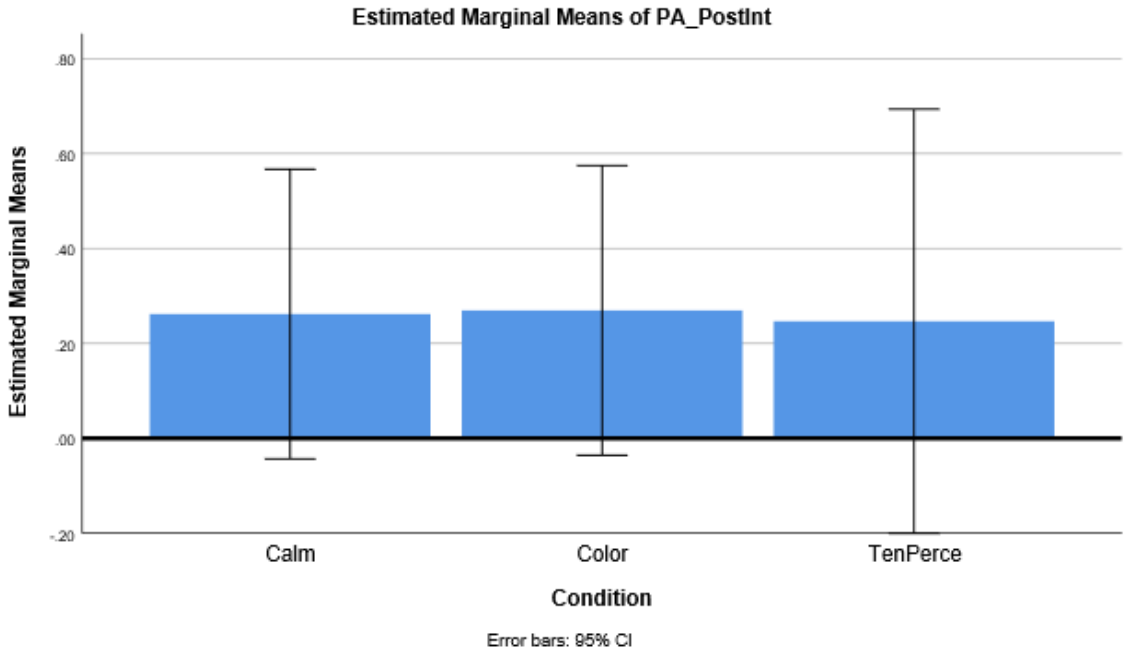

Figure 9: Positive Affect Post-Intervention

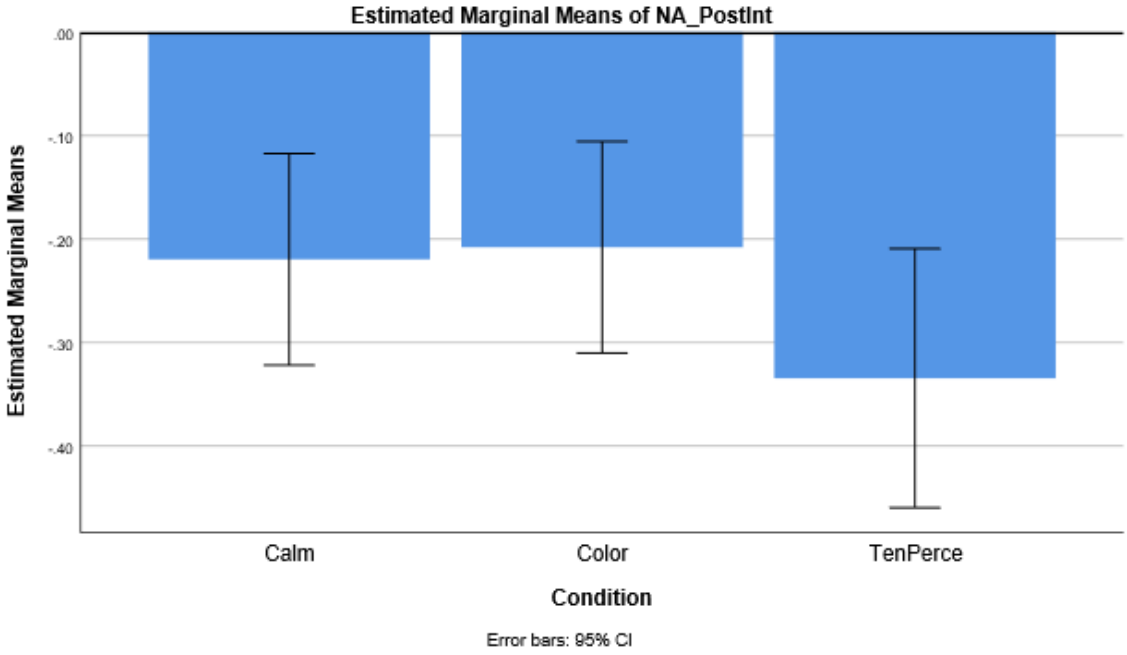

Figure 10: Negative Affect Post-Intervention

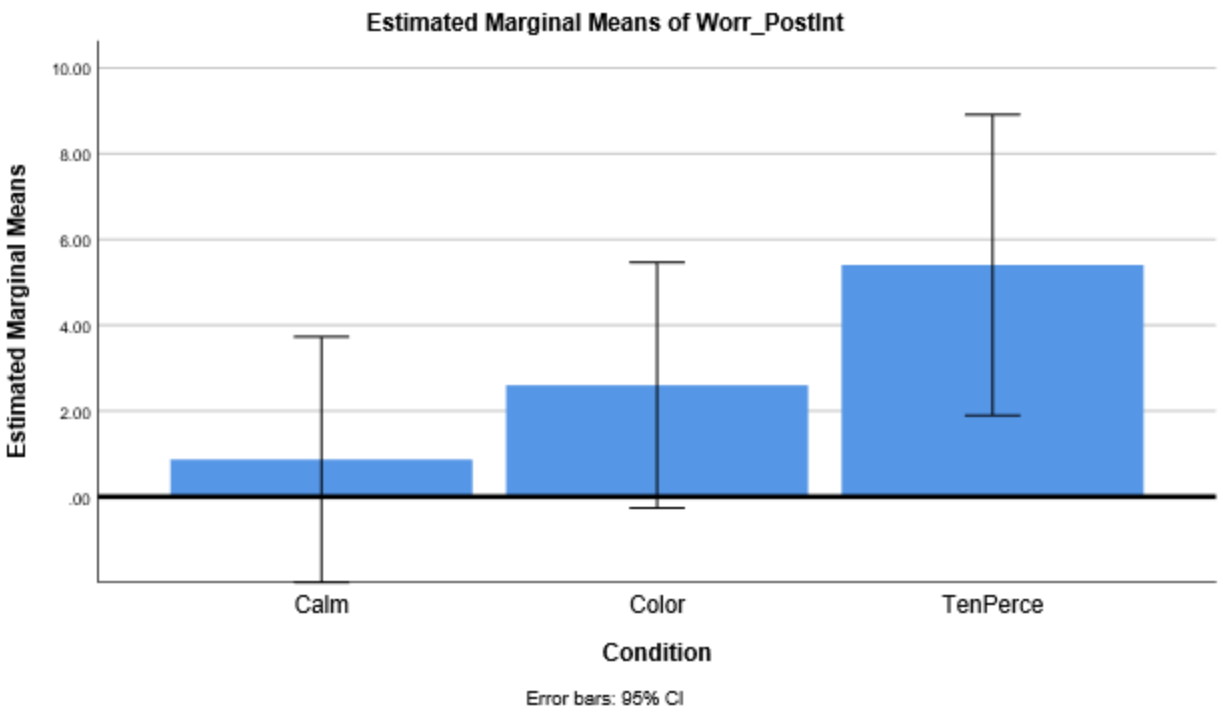

Figure 11: Worry Post-Intervention

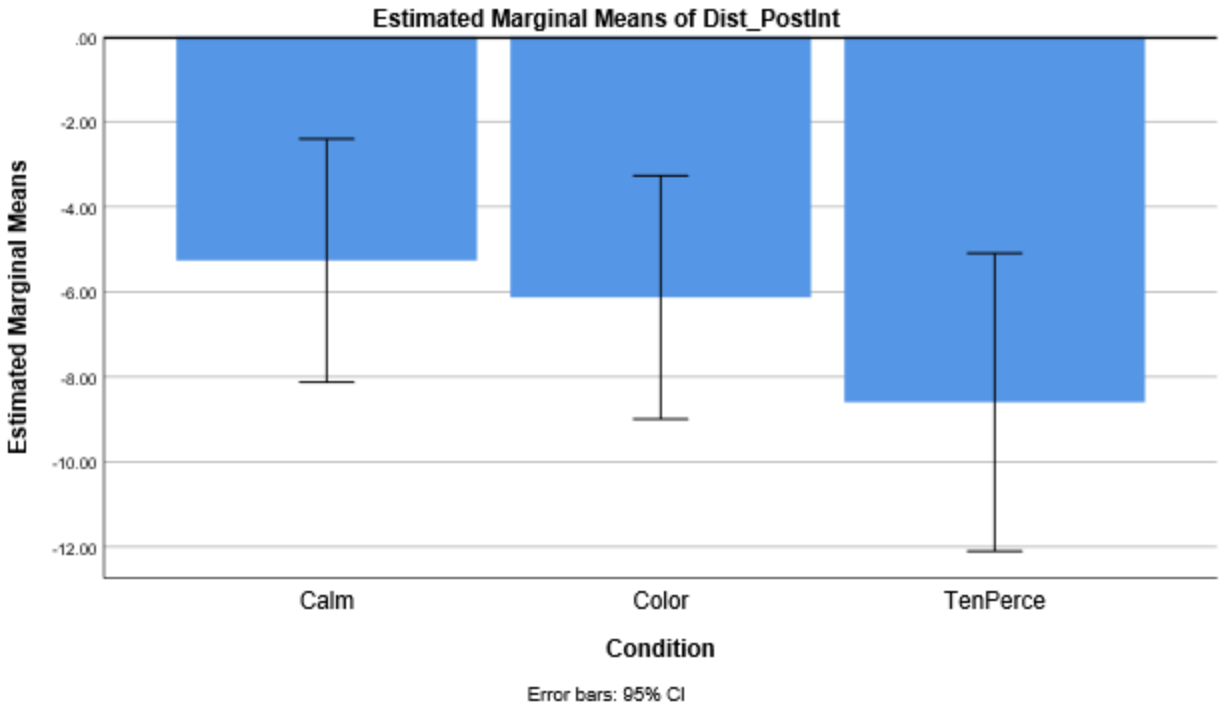

Figure 12: Distress Post-Intervention

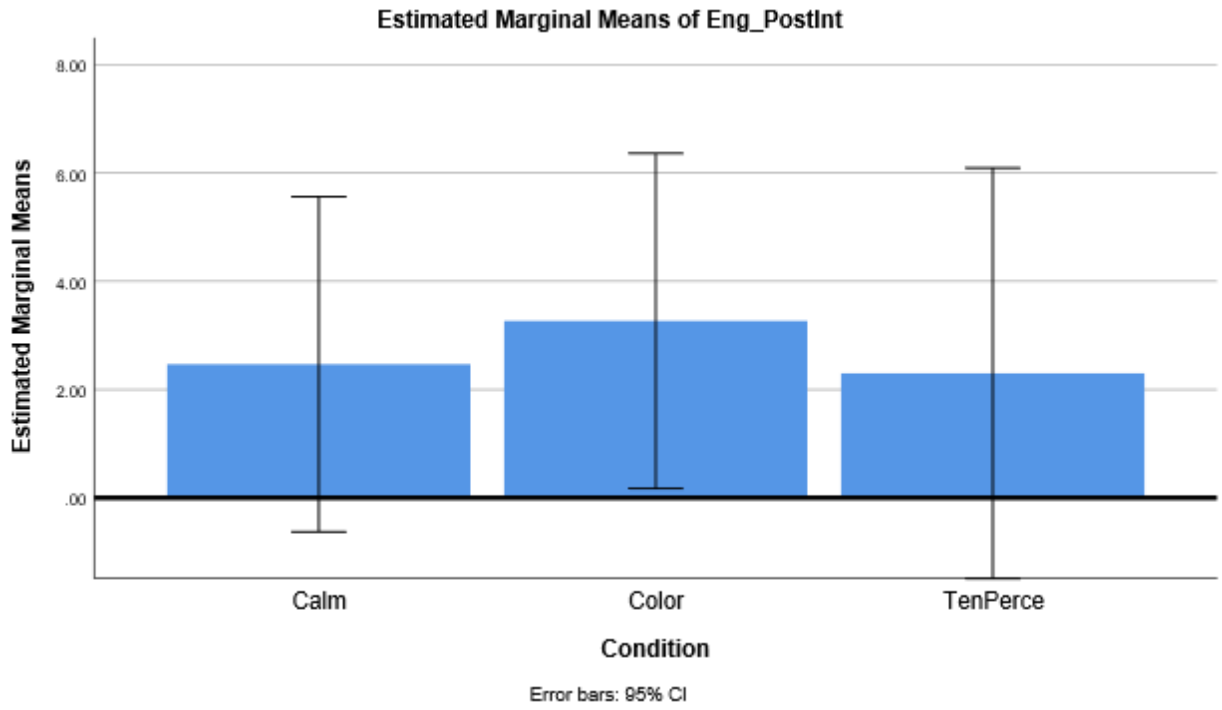

Figure 13: Engagement Post-Intervention

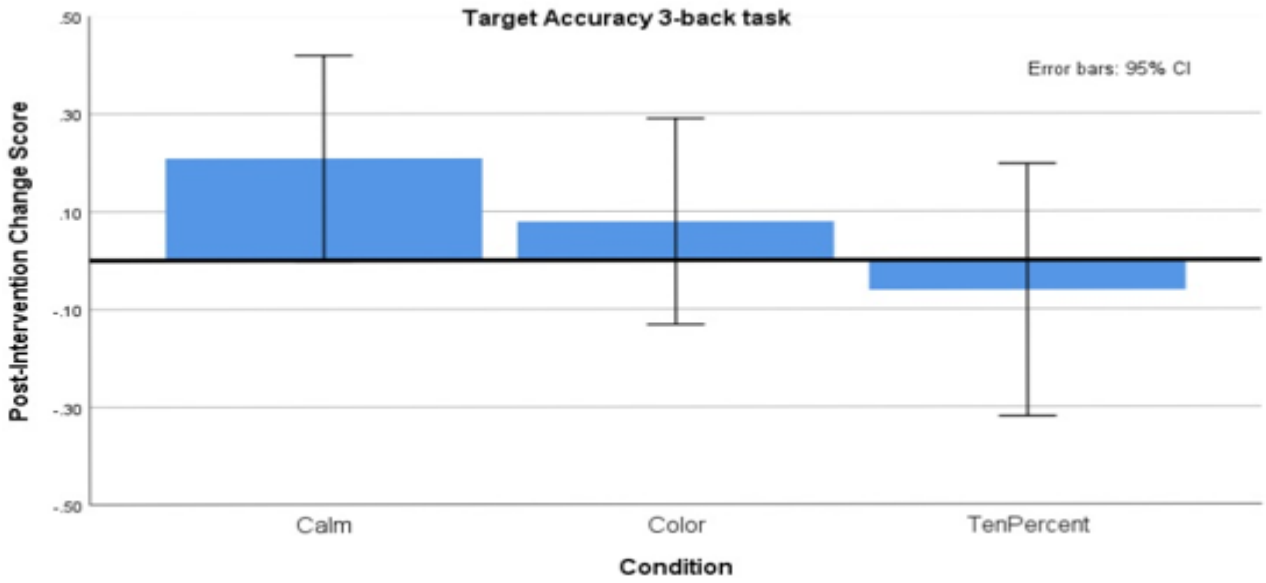

Figure 14: Post- Intervention Targeted Accuracy 3-back Tasks

Appendix B – Title Page Format

RESTORATIVE EFFECTS OF MEDITATION APPS

by

KYLE HART

A thesis submitted in partial fulfillments of the requirements for the Honors in the Major program in Psychology in the College of Sciences and in the Burnett Honors College at the University of Central Florida Orlando, Florida

Spring Term, 2020

Thesis Chairs: Dr. Daniel McConnell and Dr. Kristin Horan

Appendix C – IRB Approval

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138
Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

EXEMPTION DETERMINATION

October 17, 2019

Dear Daniel Mcconnell:

On 10/17/2019, the IRB determined the following submission to be human subjects research that is exempt from regulation:

Type of Review:	Initial Study, Exempt Category
Title:	Restorative Effects of Meditation Apps
Investigator:	Daniel Mcconnell
IRB ID:	STUDY00000891
Funding:	None
Grant ID:	None

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made, and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request so that IRB records will be accurate.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Kamille Chaparro
Designated Reviewer

Page 1 of 1

Appendix D – Consent Form

UNIVERSITY OF CENTRAL FLORIDA

EXPLANATION OF RESEARCH

Title of Project: Restorative Effects of Meditation Apps

Principal Investigator: Daniel Mcconnell

Co-Investigator: Kyle Hart

You are being invited to take part in a research study. Whether you take part is up to you.

We will investigate two commercially available smartphone Meditation apps to compare their effectiveness in stress reduction and improving cognitive function. A control group will perform a coloring book activity. Two different meditation apps, 10% Happier and Calm, will be the two experimental conditions used as an intervention. Both are health apps that are intended to help users practice a variety of mindfulness meditation exercises and help build healthy habits.

First you will take a Big Five Personality test. Then complete a baseline affective and cognitive assessment (ACA), which will include the Positive and Negative Affect Schedule, the shortened version of Dundee Stress State Questionnaire, and 3-back test of working memory span. Next, you will complete a 15 minute vigilance task that has been shown to induce mild feelings of distress and cognitive fatigue, followed by another ACA. You will then be randomly assigned to complete a coloring book, 10% Happier, or Calm for 10 minutes followed by one last ACA. Last, if you were assigned to one of the app conditions, you will complete the System Usability Scale.

The whole study will take an hour and 30 minutes.

No identifiable data will be collected during the process. De-identified data stored for a minimum of 5 years (per UCF policy)

You must be 18-29 years of age and have normal or corrected-to-normal visual acuity and color vision to take part in this research study.

Study contact for questions about the study or to report a problem: If you have questions, concerns, or complaints Dr. Daniel McConnel, Faculty Supervisor, Department of Psychology at (407) 823-4202 or by email at daniel.mcconnell@ucf.edu.

IRB contact about your rights in this study or to report a complaint: If you have questions about your rights as a research participant, or have concerns about the conduct of this study, please contact Institutional Review Board (IRB), University of Central Florida, Office of Research, 12201 Research Parkway, Suite 501, Orlando, FL 32826-3246 or by telephone at (407) 823-2901, or email irb@ucf.edu.