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Mechanisms of Meditation:

Investigating the Components and Covariates of a Single Session of Meditation

A dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy

in

Experimental Psychology

by

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The dissertation of Taylor Ellyn Bondi is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

University of California San Diego

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DEDICATION

To my family, who are my foundation and inspiration.

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LIST OF ABBREVIATIONS

INT: Intervention(s)

MED: Meditation Intervention/Condition

CON: Control Intervention/Condition

BTH: Breath Intervention/Condition

MND: Mind Intervention/Condition

DET: Detachment Intervention/Condition

EXP: Expectation Measure

SS: State Stress

SA: State Anxiety

TA: Trait Anxiety

SE: Standard Error

CI: Confidence Interval

L: Label

nL: No Label

P: Placebo

nP: No Placebo

PME: Previous Meditation Experience

SES: Socio-Economic Status

ITT: Intent-To-Treat

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ABSTRACT OF THE DISSERTATION

Mechanisms of Meditation:

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by

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Professor Karen Dobkins, Chair

Meditation research has expanded exponentially over the past few decades, establishing consistent effects of improved well-being; however, little work has focused on experimentally investigating the underlying mechanisms of *how* meditation improves well-being. Additionally, there is a consensus in the field to address sources of bias and the role of placebo and demand effects by implementing more rigorous methods. Therefore, with these motivations in mind, the

goal of this dissertation is to provide confirmatory and exploratory evidence on the effects of meditation in a series of single-session, randomized controlled trials. Chapter 1 establishes the base effect by comparing the effects of a mindful Meditation to an informational Control, which were both labelled as a "relaxation exercise" to participants, on several measures of well-being. Then, this effect is re-examined by taking into account the mechanistic role of two aspects of a person's internal state: *expectations*, or how much a person expects to improve from a session of meditation, and *thought valence*, or how positive or negative a person's thoughts were during the meditation. Chapter 2 aims to replicate and expand upon these results by comparing Meditation and Control to isolated *components* of meditation: Breath (slow breathing), Mind (meta-awareness), and Detachment (meta-awareness and detachment). Again, the mechanistic role of internal experiences is assessed. After elucidating key components and potential mechanisms of meditation, Chapters 3 and 4 aimed to explore potential sources of bias or inflated results. Using only the Meditation Intervention, Chapter 3 investigates the causal role of expectations by manipulating participant knowledge of the intervention in two ways: presence/absence of the Label "meditation", and presence/absence of a Placebo statement. Finally, Chapter 4 addresses exploratory questions on meditation efficacy and equity. Conclusively, this study (1) quantifies observable changes in well-being due to a single session of meditation, while considering the mechanistic role of internal experiences; (2) clarifies which components of meditation are necessary or sufficient to improved well-being within a single session, again looking at the role of internal experience; (3) determines how much a label and demand effects contribute to a potential placebo effect within meditation interventions; and (4) evaluates the efficacy and equity of meditation as a treatment with exploratory analyses.

Introduction

Meditation and mindfulness research has exploded in the past few decades; however, the field is still relatively new and has many unanswered questions. Mechanistic questions, regarding *how* meditation causes the numerous benefits reported in the literature, are especially at the forefront of recent interest and importance among researchers. For the purposes of this dissertation, the scope of discussion will focus on meditation research with random assignment intervention designs in non-clinical samples.

Firstly, there is incredible variation in terms and definitions of mindfulness and meditation. For instance, when discussing mindfulness, one may refer to the state, trait, training or practice of mindfulness, with varying definitions within each category. There are also many styles of meditation, with diverse histories, traditions, and perspectives. While creating a consensus and establishing norms for these terms is a necessary and important task that will take considerable time and effort in the field (Awasthi, 2013; Chiesa & Malinowski, 2011; Chiesa, 2013; Davidson, 2010; Lutz et al., 2007; Van Dam et al., 2018), the following simplified and encompassing definition offers a foundation for the studies presented in this dissertation. *Mindfulness* is the act of intentionally paying attention to the present experience without judgement. *Meditation* is a formal practice of mindfulness, often practiced by paying attention to the breath. A popular metaphor for understanding this relationship is that just as lifting weights strengthens muscles, meditation trains the brain to be mindful.

There are numerous benefits to meditation that have emerged in the literature, including better stress regulation (Goleman & Schwarts, 1976; Hoge et al., 2013; Kang et al., 2009; Maclean et al., 1997), improved psychological well-being (Galante et al., 2014; Goyal et al., 2014; Rowland-Seymour et al., 2017; Wolkin, 2015), improved cognitive function (Gard et al.,

2014; Moore & Malinowski, 2009; Tang et al., 2007; Zeidan et al., 2010), greater tolerance for pain or a lesser experience of pain (Goyal et al., 2014; Liu et al., 2013; Morone et al., 2008; Zeidan et al., 2015), and lowered stress and anxiety (Bamber & Schneider, 2016: review of 57 studies in college students; Bockstock et al., 2019; Economides et al., 2018), to name a few. However, as the field is growing, there is a consensus among reviewers and researchers for implementing more rigorous and controlled experimental designs (Brandon & Poppen,1985; Canter & Ernst, 2003; Caspi & Burleson, 2005; Chiesa et al., 2010; Davidson, 2010; Davidson & Kaszniak, 2015; Noone & Hogan, 2016; Prätzlich et al., 2016; Smith, 1975). This consensus is a result of common practices in meditation research methodology that may inflate or confound results, despite their practical convenience. Some of these common practices include biased participant recruitment methods, failure to account for placebo, demand, or treatment effects, use of wait-list, passive, or no-treatment control conditions, and extreme variability in treatment style, type, and duration.

Of note, among these concerns is a strong need for developing a theoretical framework within which meditation and mindfulness research can advance (Karunamuni & Weerasekera, 2019; Sedlmeier et al., 2012; Walsh & Shapiro, 2006). As Grossenbacher & Quaglia (2017) put it, the first step in developing these theories must be "identifying the processes intrinsic to mindfulness and meditation" (p. 1590). In order to have some confidence in identifying mechanisms of meditation, the field requires more rigorous and controlled experiments, analyses, and reporting of results (Ospina et al., 2007). Therefore, the goal of the current dissertation studies is to begin addressing these mechanisms by implementing a simplified, replicable, and highly controlled experimental approach.

Although lack of true random sampling is a pervasive source of bias in nearly all psychological research, recruitment of participants for mindfulness and meditation studies may be significantly more biased than the norm. Most studies will recruit participants by advertising, and because "mindfulness" and "meditation" have become such popular buzz words in Western culture, it cannot be assumed that a person responding to a "meditation research study" does so without pre-existing expectations, biases, interest, motivation, or beliefs. Another common practice is to recruit participants that have already signed up for, or participated in, a local mindfulness or meditation program. This method also creates a sample of participants that likely have strong personal motivations. These biased recruitment methods may result in an inflation of results (Shader & Taylor, 2017), yet this is largely overlooked. Additionally, the type of person that is interested in meditation might represent a small portion of the population, or a systematically different type of person than someone who has no interest in meditation. Failure to acknowledge or account for recruiting unbiased samples make it difficult to draw conclusions about the true effectiveness of a treatment, or how pre-existing beliefs, expectations, or biases influence observed benefits.

Relatedly, many studies lack an active control condition and instead opt for passive/no-treatment/wait-list control conditions, in which the control condition is simply a lack of an intervention rather than a comparable intervention. This is problematic because it confounds the true effects of meditation with a placebo effect (i.e., participants believe they will improve) and demand effects (i.e., participants believe they are *supposed* to improve). In other words, there is no way to generate clear results about the magnitude of meditation benefits independent from participating in a research study or from participating in any intervention (Dunning et al., 2019; Price et al., 2008; Slemp et al., 2019). As Hróbjartsson & Gøtzsche (2001) showed in a meta-

analysis of clinical trials (*N*=130 trials, *N*=8,525 participants), a placebo shows benefits compared to no-treatment for continuous subjective outcomes and for treatments of pain, both common in meditation research. Some researchers have started to address the placebo effect by equating expectations across conditions, thus isolating the true effects of meditation. This approach was developed by Fadel and colleagues (2010; 2015), who compared a meditation intervention to a "sham" meditation intervention, in which participants are guided through deep breaths but do not actually practice mindfulness techniques. These studies showed benefits (to mood, cardiovascular health, and pain relief) from meditating above and beyond placebo and demand effects. As these studies show the importance of considering placebo effects, the current dissertation studies aim to examine potential sources of inflated expectations. While Fadel and colleagues equated expectations about different interventions, the current dissertation manipulates expectations about the same meditation intervention (see Chapter 3).

Another limitation of the vast majority of studies looking at the benefits of meditation is that there is a lot of variation: in study duration (from days, to weeks, or months of participation), in session duration (from as short as 5-minute sessions to 1-hour sessions or week-long immersive retreats), and in meditation instructions (from body scans, to open-monitoring, to breath work). This variability ambiguates causal mechanisms, effect sizes, and optimal treatment conditions. By starting from shorter and simplified interventions, it becomes feasible to ask mechanistic questions, from which a theoretical framework and standardized treatments can be built. In other words, it is much easier to manipulate and test mechanistic and contextual variables across conditions when the intervention lasts one day, as opposed to several months. Very little research has been done with a smaller time frame. By examining the effects of a single session of meditation, mechanisms and contributing components of meditation can be

isolated and tested for improvements in state well-being, which may differ from long-term mechanisms underlying the effects of repeated meditation practice. Establishing key causal mechanisms from a single session of meditation is a foundational first step in building more comprehensive, theoretical frameworks for how meditation improves well-being. Because there are likely multiple components of meditation that may causally contribute to improved well-being, comparing the effects of each component is the most feasible and easily interpretable in the context of a single session of meditation.

Which component(s) of meditation are likely the strongest contributors to improved well-being? Is mindfulness, the practice of noticing one's thoughts without reaction, judgement or attachment, sufficient to improve well-being? What is the mechanism of improvement, a "detachment" from one's thoughts? Or, perhaps practicing mindfulness during meditation simply leads to having fewer thoughts, or fewer negative thoughts. Related research on thought content has shown that people report feeling happier when their thought content is more positive (Guo & Dobkins, 2020; Killingsworth & Gilbert, 2010). Or perhaps simply the practice of slowly breathing, or the expectation of relaxation and improved mood, is sufficient to improve well-being. This study aims to disentangle some of these components of meditation and determine *how* a session of meditation improves well-being. Particularly, these studies will ask which component of meditation contributes to improved well-being? The three main components that will be compared are (1) slow breathing, (2) meta-awareness, or being aware of and observing one's own thoughts, and (3) detachment, or letting go of thoughts without reaction or judgement. Additionally, in order to better understand the underlying mechanisms of improved well-being, these studies will both measure and manipulate expectations of improvement, and investigate the

role of thought valence—how positive, neutral, or negative one's thoughts are—during a single session of meditation.

By implementing a pre-registered, single-session intervention design, these studies aim to address these methodological issues and reduce confounds, error, and bias as much as possible. To reduce biased recruitment, the studies were listed among a list of potential studies available for participation and did not state the words "meditation" or "mindfulness" in the title, description, or consent form. Participants were recruited from two populations, one undergraduate and one national (via Prolific), with the latter having the option to recruit a "representative" sample of the United States based on age, sex, and race. Active control interventions were developed in parallel with the meditation interventions as pre-recorded guided audio recordings, and double-blind random assignment was possible through an online survey tool. Additionally, this study both measured and manipulated expectations associated with the word "meditation" and with participating in a research study. Therefore, not only does this create a less biased sample, but also allows us to assess what role these biases and expectations play in any observed benefits.

As well as reducing confounds and bias as much as possible, these dissertation studies aim to identify key components of meditation that drive improvements in well-being and to understand underlying mechanisms of improvement. Specifically, Chapter 1 establishes the effects of a single session of meditation on well-being by comparing a 20-minute meditation to a 20-minute informational control intervention. Then, these effects are re-evaluated by taking into account the roles of expectation (of improvement) and thought valence (from negative to positive), in order to gain a better understanding of potential mechanisms of improvement (i.e., as mediators or moderators). Chapter 2 aimed to replicate these effects while also comparing the

meditation and informational control interventions to three additional "component" interventions, which isolate specific components of meditation: slow breathing, meta-awareness, and detachment. Again, these effects are re-evaluated in relation to expectations and thought valence. Then, Chapter 3 assesses the placebo effect and label bias by comparing the same meditation intervention presented as: either a "meditation" or a "relaxation exercise", and presented with either a placebo statement ("this exercise is expected to improve your well-being") or nothing. Finally, Chapter 4 contains exploratory analyses addressing the role of various psychological traits, behaviors, and demographics on degree of improvement from a meditation in order to better contextualize and understand the effectiveness and equity of meditation as a treatment.

There are 21 pre-registered tests throughout Chapters 1, 2 and 3 (Chapter 4 is exploratory). Primary Analyses determine the effect of condition on Primary Variables (main outcome variables: State Stress, State Anxiety, and Trait Anxiety). Therefore, there are 3 tests in the Primary Analyses of each chapter, 9 in total. Secondary Analyses assess the role of Secondary Variables (Expectations, Thoughts) on State Stress and State Anxiety, disregarding Trait Anxiety as it was not expected to change. Therefore, there are 4 tests in the Secondary Analyses in each chapter, 12 in total. These analyses will use a Bonferroni familywise error rate correction. Based on 21 planned tests (in Chapters 1, 2 and 3), the alpha value of $p = 0.05$ will be adjusted to a critical value of $p = 0.002$ for each individual test. Finally, Tertiary Variables will be assessed in the exploratory analyses in Chapter 4. Although specific questions and trends were pre-registered, this section was designated as exploratory and had no planned analyses.

Chapter 1: Effects of a Single Session of Meditation

Introduction

Can a 20-minute session of mindful meditation improve well-being? How does meditation influence one's expectations of improvement? How does meditation influence one's thoughts? Conversely, maybe expectations and thoughts influence well-being or interact with meditation. This study aimed to provide insight into these questions by comparing participants responses to several aspects of well-being after participating in a "relaxation exercise", which was either a mindful Meditation exercise or an informational Control exercise.

Meditation research has largely focused on long-term practice, the most common intervention being an 8-week mindfulness training such as MBSR, MBCT, or a similarly structured program (Eberth & Sedlmeier, 2012). The goal of these studies has often been to answer the question "what are the benefits?". Now that these benefits to well-being have been reasonably established (Gál et al., 2021; Goyal et al., 2014; Khoury et al., 2015), the question to answer now is "how does meditation create these benefits?" With the goal being to understand mechanisms, it is much more feasible to effectively isolate variables in a single-session intervention design. However, are there observable improvements within a single session of meditation? Only a few studies have looked at the short-term effects of meditation or effects of a single session. A recent study found that one, 25-minute session of meditation reduced self-reported stress, but not physiological measures (Colgary et al., 2020). Andreu and colleagues (2018) used EEG to show that 15 minutes of mindfulness training produced enhanced response inhibition (i.e., less effortful suppression) in smokers, suggesting that even one session may alter brain patterns. And behaviorally, Liu and colleagues (2013) showed that 15 minutes of mindfulness training improved pain tolerance and reduced distress during a cold-presser task.

These studies suggest that there are observable and measurable changes following one session of meditation. If we can observe changes in well-being after a single session of meditation, then we can begin to ask more specific questions about underlying mechanisms and isolate components of meditation that drive improvements.

One source of improvement independent from the practice of meditation itself may be one's internal state, or how open they are to potential improvement. This study identifies two potentially influential aspects of one's internal state: expectation of improvement and thought valence. First, an expectation of improvement may enhance or completely explain observed benefits, which would demonstrate that there may be a "placebo effect" contributing to the effects observed in the literature. Expectations have been studied in a small number of meditation studies, expressing the difficulty in disentangling this from the efficacy of meditation itself. As Farb (2014) suggests, an expectation of immediate relief may not only inflate results, but it is also counter-intuitive to the original Buddhist practices, in that an attachment to "happiness" is just as detrimental as an attachment to pain. Farb (2012) also posits the importance of studying expectation in meditation research going forward in order to disentangle its unique effects and to develop generalizable and effective treatments.

Second, thought valence—how positive or negative one's thoughts are—may be a more powerful influence on well-being than any external influence or guided prompts. Additionally, meditation may alter the valence of thoughts, or change the influence of thoughts on well-being. Thought valence may provide insight into the mechanisms of meditation by revealing how meditation might interact with our thought content or thought valence. For example, meditation might make positive thinking more likely; alternatively, meditation may change our relationship and reaction to negative thinking. The relationship between thoughts and mood has mostly been

studied in the context of mind-wandering, showing that a wandering mind is less happy than a mind focused on the present moment, especially when the valence of wandering thoughts is negative (Banks et al., 2016; Guo & Dobkins, 2020; Killingsworh & Gilbert, 2010). Similarly, Smallwood and colleagues (2009) showed that inducing a negative mood increases mind-wandering. As mind-wandering is in some ways an opposing construct to mindfulness, researchers have begun look for insights in merging these fields and theories (Mrazek et al., 2012; Schooler et al., 2014). One study not only showed a negative correlation between dispositional, or trait, mindfulness and frequency of negative thoughts, but also a decrease in negative thoughts following a mindful meditation intervention (Frewen et al., 2008). This suggests that meditation may change the content of thoughts, which may or may not be compatible with meditation changing the relationship with one's thoughts.

This study not only aims to establish observable changes in well-being within a single session of meditation, but more importantly to understand contributing mechanisms of how these changes occur. Does a single session of meditation improve well-being? Does an expectation of improvement or thought valence improve well-being? Does meditation affect the valence or influence of thoughts? In these studies, well-being is defined as state stress and state anxiety. Chapter 1 aims to (a) establish that there are observable improvements in state well-being due to a single session of meditation, and to (b) ask whether these improvements are/are not influenced by participants' expectation of improvements and/or thought valence.

Methods

This study follows a standard intervention, pre-post design. Participants were randomly assigned to one of two "relaxation exercises," either a mindfulness Meditation or an

informational Control, and filled out measures before and after on various aspects of well-being, personal behaviors, traits, and basic demographic information.

Participants and Recruitment

Participants were recruited via SONA, an online sign-up tool for undergraduates at UCSD to participate in research studies in exchange for extra credit in certain courses. This is particularly advantageous for the goals of this study because SONA lists study information by a code of letters and numbers rather than a title or advertisement. Therefore, participants had no prior knowledge (and by extension, no pre-existing biases) about the fact that they would be participating in a *meditation* study, a key difference from nearly all meditation studies to date. This allowed us to measure expectations about study participation based on the limited but controlled information provided.

Power Analysis. Based on pilot data, the effect size was calculated from the differences in mean improvement scores of state anxiety between a 30-minute meditation and a 30-minute nature movie control intervention. Using a standard calculation based on the *F*-test of this comparison, the resulting effect size is $d = 0.42$, 95% CI [0.07, 0.77] (Wilson, 2019). Using a different calculation method (e.g. using raw "pre" and "post" scores and standard deviations of state anxiety rather than the *F*-statistic on normalized mean difference scores), the resulting effect size is $d_{ppc2} = 0.283$ (Morris, 2008). Therefore, due to the low sample size from the pilot study and a large confidence interval on the effect size, an average effect size of $d = 0.35$ (i.e. $f = 0.175$) was used to calculate the N required to detect an effect of meditation for each study stage. Therefore, for an a priori *F*-test, using $f = 0.175$, Bonferroni-adjusted alpha = 0.002, power = 0.8, and 2 covariates, the required number of participants needed to detect an effect is $N = 913$, or $n =$

91 in each of the 10 conditions (across all studies in Chapters 1 to 3). We decided to aim for *n* = 100 participants in each of our conditions.

Pre-registration

This study was pre-registered on December 16, 2020 through the Open Science Framework (OSF). Link to the pre-registration page: https://osf.io/hftnq. An amendment to the pre-registration was added on June 10, 2021. The amendment added a new condition to Part 2 (see Chapter 2) and a new analysis to the Tertiary Analyses (see Chapter 4), but contained no alterations or changes to the original pre-registration. All pre-registered details have been followed.

Platform

Participants signed up for and completed this study online. The entire study, which was available through a single survey link, took about 30-45 minutes to complete, and required a stable internet access and working audio. Participants were directed to the study link, which began with the basic study description and consent form. This was followed by questions about moods, thoughts, and behaviors, followed by "pre" outcome measures. From this point, participants were randomly assigned into one of the two possible interventions. First, participants read short instructions for the "relaxation exercise" they were are about to participate in and answered a single question about expectations of improvement. After confirming that they have working audio (i.e., speakers or headphones), they proceeded to the next page with the exercise. Each intervention was 20 minutes and was available as a playable audio file on the page or had the option to be downloaded. Participants did not have the option to continue forward with the study until 20 minutes had passed on the page with the intervention audio file. Once 20 minutes

had passed, participants continued to complete the post-questionnaires, demographics, and exit questions.

Interventions

Each intervention was a 20-minute, guided relaxation exercise. Note, Intervention refers to the intervention itself, the guided audio-recording with specific instructions, and Condition refers to experimental groups. These correspond in Chapters 1 and 2, as each Condition receives a different Intervention, and the terms can be used interchangeably. However, in Chapter 3, several Conditions receive the same Intervention, so this distinction is made here. Participants in each intervention were told that they would participate in a "relaxation exercise", avoiding indications of the words, "mindfulness" and "meditation" or whether they were in the control or experimental conditions. Before beginning the intervention, participants read a short description of the relaxation exercise they were are about to participate in. Each description was the same, differing only by the last line, which gave a brief description (one sentence) of their assigned intervention (see *Appendix)*. Then they answered the expectation question before proceeding to the intervention page. Participants listened to their assigned intervention via an audio recording. Each intervention followed the same structure, with intervals of instruction and pauses. The recordings began with the instructions to close the eyes and relax, followed by the intervention-specific instructions, which were more frequent for the first 8 minutes, about every minute for the next 5 minutes, and mostly silent practice for the last 7 minutes. All interventions were pre-recorded and voiced by a professional meditation and mindfulness workshop instructor, Nadia Horvath. Full scripts, with timing indicators and preliminary descriptions, are available in the *Appendix*.

Meditation Intervention. Participants were guided through a 20-minute mindful meditation. This was the main "treatment," or "experimental" condition. This meditation intervention was a 20-minute guided recording of a mindfulness meditation, following the philosophy and style of Vipassana meditation. Participants were instructed to focus on the flow of their breath (breathing through their nose), and if a random thought arises, to passively notice and acknowledge the thought and to simply let it go by bringing their attention back to the sensations of their breath. Mindfulness meditation was chosen because it is one of the most popular forms of meditation in Western culture today, and it is most often used in RCTs of new or novice meditators.

Control Intervention. Participants listened to a 20-minute informative narration about various relaxation techniques, and the science and benefits of these exercises. In this condition, there were much fewer and much shorter pauses in order to minimize the likelihood that participants will be able to reflect or practice the techniques being discussed. Additionally, the narration only discussed relaxation techniques that could *not* be practiced while listening (e.g., activities like stretching, listening to music, and journaling). There were short pauses between each technique or scientific study discussed, where participants were asked to think about simple questions related to methods, implications, or study results. This condition was voiced by the same narrator, and participants were still given the same introductory instructions to relax and close their eyes; therefore, this condition still closely matched the physical experience of the other interventions.

Measures

There are three levels of variables included in this study:

1. Primary variables are the main outcome measures, and are analyzed for improvement in well-being pre- to post-intervention.
2. Secondary variables are key covariates of interest, and are analyzed to see how internal experiences influence improvements in well-being.
3. Tertiary variables are exploratory covariates, and are analyzed to reduce noise in the outcome measure as well as to see various traits, behaviors, or prior experience moderate improvements in well-being. These are mentioned here because they were collected as a part of this study, but the details, analyses, and discussion of these variables may be found in Chapter 4.

Primary Variables. Primary Analyses look at improvements in well-being as a result of the interventions. In this study, well-being is defined as and measured by state anxiety, stress, and general mood. The following questions and standardized questionnaires were given to participants to fill out before and after the intervention. These are the only variables measured twice; all others are measured once. Normalized difference scores pre- to post-intervention are analyzed to determine improvement in well-being.

- State Anxiety: State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). This is a 40-item test (20 state and 20 trait), which measures the presence and severity of current symptoms of anxiety and a generalized propensity to be anxious. It is set up as a 4-point Likert- scale from 1 (“Not at All”) to 4 (“Very Much So”). Normalized scores are calculated by dividing the scores by the highest potential score. State and Trait anxiety

are analyzed as separate measures, with Trait Anxiety acting as a check on demand effects as it was not hypothesized to change.

- Stress: A composite score of state stress was calculated by combining the responses to 3 questions. The first two questions have slider scales from 1 to 10, with labels on each end and number markers in between, and the third question uses a 5-point visual analog scale. The first question asks: "How stressed do you feel right now?" (1 = not at all stressed, 10 = extremely stressed). The second question similarly asks: "How relaxed do you feel right now?" (1 = not at all relaxed, 10 = extremely relaxed). And finally, the third question asks: "How are you feeling right now?" and has a simple, traditional, yellow-and-black smiley face that can be adjusted from the neutral middle (starting point) to up to 2 points in the positive direction (making the face slightly and then fully smile) or up to 2 points in the negative direction (making the face slightly and then fully frown). "State Stress" is then calculated with the following equation: (stress + (11-relax) + (2*(6-feel))/30, such that a higher score indicates more stress.

All analyses were done on normalized difference scores, calculated by subtracting the pre raw score from the post raw score, and dividing the difference by the maximum score of the question or standardized questionnaire (post-pre/max). Therefore, results indicate normalized change, or percent change in relation to the entire scale (i.e., percent of the whole range, rather than in relation to the "pre" score).

Secondary Variables. Secondary Analyses look at the role of a person's internal state on improvements in well-being. The role of participants' expectations of improvements, as well as the valence of their thoughts, have not been studied in the context of a (single session)

meditation intervention. For any observed benefits in well-being seen in the primary analyses, the following variables were assessed for their mediating or moderating role.

- Expectation: Few studies have attempted to measure participants' expectation of improvement prior to participation in meditation (or control) interventions. This was the last question of the pre-intervention questionnaires, following the short description of the "relaxation exercise" the participant was about to begin. The question simply asked: "How do you expect to feel after this 20-minute relaxation exercise?" and was assessed with a 100-point slider scale. Numbers on this slider scale were used for analysis, but did not appear to participants. Rather than numbers, the scale only showed five, evenly spread, verbal statement markers: "I think I will feel much worse; I think I will feel worse; I think I will feel the same; I think I will feel better; I think I will feel much better."
- Thoughts: All interventions involve participants sitting silently for 20 minutes, which naturally entails turning inward to your own thoughts. Because internal thoughts may prove more powerful than any external instructions, it is important to ascertain whether these thoughts might influence mood, stress, or anxiety. Therefore, all participants were asked in the post-questionnaires about the valence of their thoughts (i.e., how positive, negative, or neutral their thoughts were) with the following questions:

    1. Thought Valence
        a. "Imagine someone read the transcript of what you thought about in the 20-minute exercise. How would they rate the content of that transcript?" [7-point scale with 3 labels: very negative, neutral, very positive]

b. Confidence: “How confident are you about your estimate above?” [7-point scale, 3 labels: Not at all, Moderately, Completely/Entirely]

2. Positive Thoughts Percent
    a. Percentage: “Imagine someone read the transcript of what you thought about in the 20-minute exercise. What percentage of the content would that person say is “positive content”, e.g., has a positive attitude, contains compassion (for self or others), has helpful insight/understanding, etc.?” [100-point slider scale for “Percent Positive”]
    b. Confidence: “How confident are you about your estimate above?” [7-point scale, 3 labels: Not at all, Moderately, Completely/Entirely]
3. Negative Thoughts Percent
    a. Percentage: “Imagine someone read the transcript of what you thought about in the 20-minute exercise. What percentage of the content would that person say is “negative content”, e.g., has a negative attitude, contains little compassion (for self or others), has little insight/understanding, etc.?” [100-point slider scale for “Percent Positive”]
    b. Confidence: “How confident are you about your estimate above?” [7-point scale, 3 labels: Not at all, Moderately, Completely/Entirely]

The order of these questions remained constant, and each question was presented on a separate page. Thought Valence (1) is the main *Thoughts* measure, which was modestly validated with the positive (2) and negative (3) percentage ratings. Although this measure is difficult to validate due to the nature of assessing internal experiences, we can gain some confidence in its validity by comparing confidence scores with the correlation of

the two forms of the question. Specifically, the correlation between (1) and (2) should be similar to the correlation between (1) and (3), and the strength of this correlation is expected to increase with an increase in confidence ratings. [See *Preliminary Analyses*, below, for confirmation of these pre-registered predicted trends].

Tertiary Variables. These exploratory variables, which were collected with this study, are described in Chapter 4. Tertiary analyses are mostly exploratory in nature, with the goal of further clarifying individual effects of condition on improved well-being by reducing noise and finding the best model, as well as determining moderating effects of variables that have previously shown to correlate with meditation effectiveness. See Chapter 4 for analyses and discussion.

Inclusion Criteria

Because this was an online study, reliability and validity of data was more of a concern. These methods were employed in order to remove participants that did not give their full attention and effort to the study.

- Attention Checks: Throughout the survey, there were 7 attention check questions hidden within questionnaires. These questions said something like, "If you are paying attention to this survey, please select [blank]", and were scored correctly if participants chose the indicated response. Participants must get at least 6 of the 7 attention checks correct (e.g., participants cannot miss more than 1).
- Engagement: At the end of the survey, participants were asked a few questions about their engagement during the study: "How *engaged and focused* were you while listening to the guided instructions" was answered on a 10-point slider scale, with 3 verbal markers

(Not at all, Somewhat, Completely). Participants must answer a 5 ("Somewhat") or greater.

- Subjective Validity: There were two questions at the very end of the survey that asked participants to rate their effort and attention levels throughout the study. Participants were told that their responses to these questions was still completely anonymous, and would not in any way affect their compensation, but is used to improve the validity of data included in our analyses. This additional validity measure was implemented because of the uncertainty and lack of surveillance with an online, remote study. The first question asked about their attention and effort while filling out survey responses, and the second asked about their attention and effort while listening to the guided instructions during the exercise. Participants must choose the highest of 4 engagement levels for both questions. Although we could not assess whether participants answer the second question (about listening to the guided instructions during the exercise) truthfully, we could validate the first question (about filling out survey responses). If we consider correctly answered Attention Check questions as an *objective* validity measure of survey attention, we can use it to validate the *subjective* validity question for survey attention. First, looking at the entire sample (before exclusions), how many participants subjectively reported full attention but failed more than one attention check? Of the $N = 426$ participants that subjectively reported full attention, $n = 12$ failed more than one attention check. In other words, based on the subjective validity question alone, we have reasonable confidence that about 97% of included participants gave acceptable effort and attention to the surveys. [Note, this is bumped to 100% in the actual sample because Attention Checks are also used as an inclusion criteria]. Assuming participants answer

both subjective validity questions using the same method of self-assessment, we can also have reasonable confidence that about 97% of the sample who reported giving full attention to the exercise actually gave acceptable effort and attention.

Analysis Plan

Because little research has been done in the context of such a short time-frame, and nearly no research has investigated the mechanistic role of these "internal state" variables, it is important to first establish the simple effect. Therefore, Primary Analyses ask if there is a difference in a change in well-being between participants in the Meditation and Control conditions. (Pre-registered) predictions include greater improvements in well-being in the Meditation condition compared to Control, and more improvement in the state, not trait, measures of well-being. Then, Secondary Analyses address the role of expectation and thought valence, to ask whether these explain improvements in well-being seen in the Primary Analyses.

The following analyses will use a Bonferroni familywise error rate correction. Based on 21 planned tests (in Chapters 1, 2 and 3), the alpha value of $p = 0.05$ will be adjusted to a critical value of $p = 0.002$ for each individual test.

Results

Preliminary Analyses

Exclusions. Data collection continued until, after running the inclusion criteria code, there was a minimum of 200 participants (from the goal of 100 per condition). Data was collected from a total of N=525 participants. Consecutively, n=12 participants were removed for not finishing the study, n=26 were removed for failing more than one attention check, n=48 were removed for failing the subjective general engagement question, n=54 were removed for failing the survey subjective validity question, and finally n=178 were removed for failing the

intervention subjective validity question. Therefore, the final sample of *N*=207 (115 Meditation, 92 Control) participants very likely gave their full effort and attention to participating. See *Inclusion Criteria*, above, for details on these items.

Demographics. This study had a sample of *N*=207 undergraduate students, with a mean age of 20.7 years (with a SD of 2.7). There were 168 (81%) who identified as female, and 39 (19%) as male. There were 106 (51%) students who identified as Asian, 40 (19%) as Hispanic or Latino, 35 (17%) as White, 5 (2.5%) as Black or African American, 3 (1.5%) as Middle Eastern or North African, 14 (7%) as Mixed, and 4 (2%) preferred not to answer. There were 23 (11%) Freshman, 27 (13%) Sophomores, 95 (46%) Juniors, 58 (28%) Seniors, and 4 (2%) Fifth years.

Thoughts Measure Validation. Thought Valence (1, above) is the main *Thoughts* measure, which can be modestly validated by comparing it with the related questions of positive (2) and negative (3) thought percentage ratings. Although this measure is difficult to validate due to the nature of assessing internal experiences, we can gain some confidence in its validity by comparing confidence scores of Thought Valence with the correlation of the two forms of the question. These pre-registered predictions on how these questions correlate add reasonable confidence in the measure. Specifically, the correlation between (1) and (2) should not only be high, but also similar in magnitude to the correlation between (1) and (3). As expected, the correlation between Thought Valence and the other two measures of percentage of positive and negative thoughts show similar patterns ($r = 0.58$, $p < 0.000$; $r = -0.46$, $p < 0.000$, respectively). Additionally, the strengths of these correlations are expected to increase with an increase in confidence ratings, showing that as participants respond more reliably to the different forms of the question, they also report higher confidence in their responses. Again, the data is consistent with this prediction (see Figure 0.1) showing that we can reasonably trust participants'

confidence ratings. Looking at these confidence ratings, only *n*=5 participants reported less than somewhat confident (less than a "4" on the x-axis of Figure 0.1) on the main Thought Valence (*Thoughts*) measure, and no one reported little to no confidence. Therefore, 98% of the sample reported moderate to complete confidence in their response to the Thought Valence question, and we have reasonable evidence to validate the *Thoughts* measure.

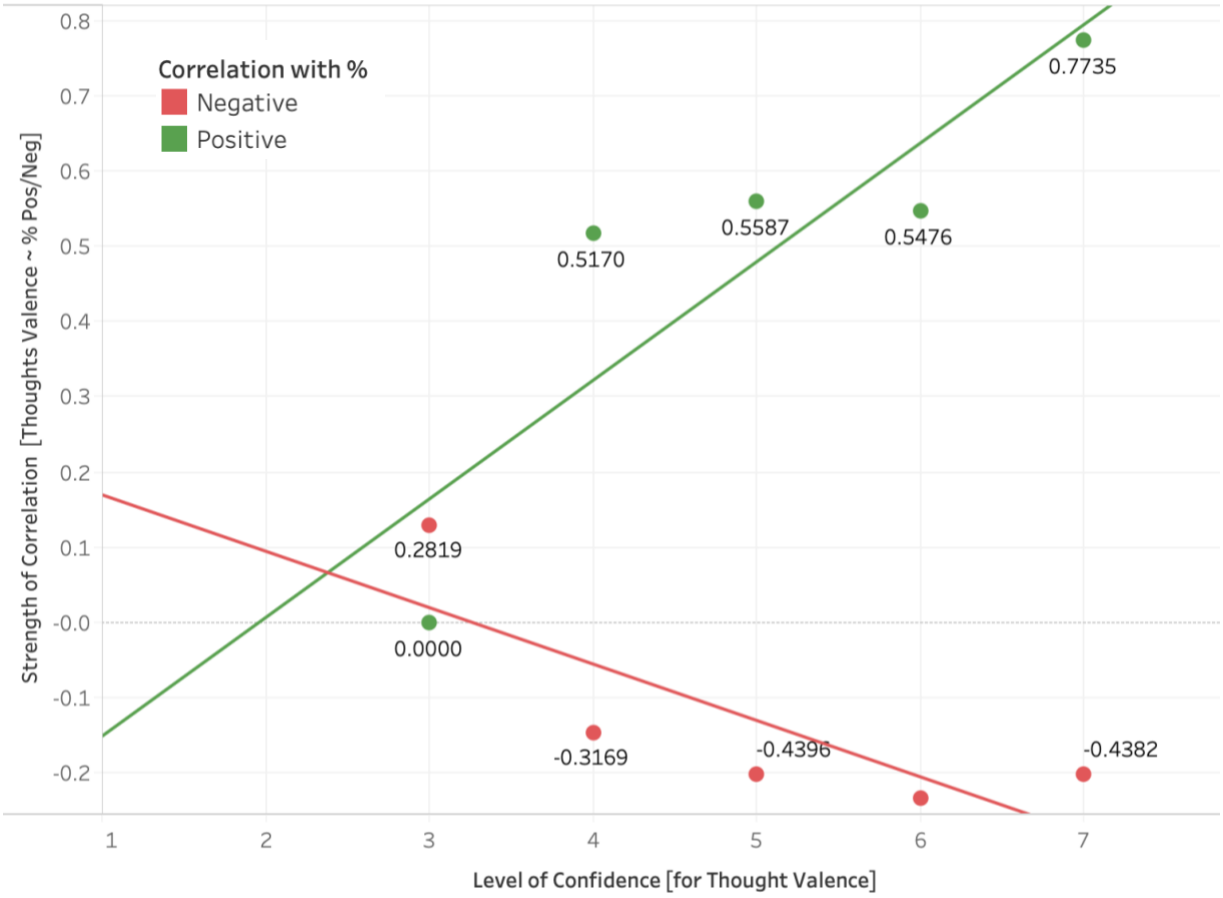


Figure 0.1 *Thoughts Measure Validation*

Note. Higher confidence scores in Thought Valence is associated with higher reliability between different forms of Thought questions. Values shown are Pearson's r correlation between Confidence Ratings for Thought Valence and the strength of the correlation between Thought Valence and Thoughts [Positive/Negative] Percentage. Confidence scores ranged from 1 to 7 [1: not at all, 4: somewhat, 7: extremely].

Primary Analyses: Comparing Meditation and Control

Are there any benefits to well-being after 20 minutes of mindful meditation compared to 20 minutes of listening to information about relaxation techniques? Normalized difference scores, indicating absolute percent change from before to after the 20-minute Intervention, were calculated for the three measures of well-being: State Stress (SS), State Anxiety (SA), and Trait Anxiety (TA). These were calculated by subtracting the post-Intervention scores from the pre-Intervention scores, and dividing the difference by the maximum score of the scale (post-pre/max). Note that pre-scores for each of these measures did not differ between the Meditation and Control conditions (SS: $t(205) = -1.48$, $p = 0.14$; SA: $t(205) = -0.83$, $p =$. 0.41; TA: $t(205) = -0.71$, $p = 0.48$).

A one-way *ANOVA* on normalized difference scores for State Stress, State Anxiety, and Trait Anxiety revealed a marginally significant effect of Meditation on State Stress ($F(1,205) = 7.72$, $p = 0.006$), a trending effect on State Anxiety ($F(1,205) = 3.31$, $p = 0.07$), and as expected, no effect on Trait Anxiety ($p > 0.6$). Mean reduction in State Stress was -0.2014 (SD: 0.16) for Meditation and -0.1399 (SD: 0.16) for Control (see Table 1.1). In other words, meditation reduced State Stress by 20% overall, which was 6% more than the Control group (see Figure 1.1). Although the *p-value* for the effect of state stress barely misses significance based on strict multiple comparison corrections, there is a medium effect size of d=0.39. This provides evidence that a single session of meditation is sufficient to improve state well-being.

Table 1.1

Means, Standard Errors, and Effect Sizes (Cohen's d) of Change in State Stress, State Anxiety, and Trait Anxiety for Meditation (MED) and Control (CON) Conditions (N=207)

Measure	*Mean Difference [and Standard Error]*		Cohen's *d*
	MED	*CON*	[95% Confidence Interval]
State Stress*	-0.20 [.015]	-0.14 [.016]	0.39 [0.11, 0.66]
State Anxiety	-0.13 [.012]	-0.10 [.012]	0.25 [-0.02, 0.53]
Trait Anxiety	-0.05 [.006]	-0.04 [.005]	*NA*

Note. Means are normalized difference scores from pre- to post-Intervention. Effect size for Trait Anxiety was not calculated because there was not a significant effect. For Cohen's *d*, a small effect is 0.2, medium is 0.5, and large is 0.8. * $p < .01$, ** $p < .001$, *** $p < .0001$.

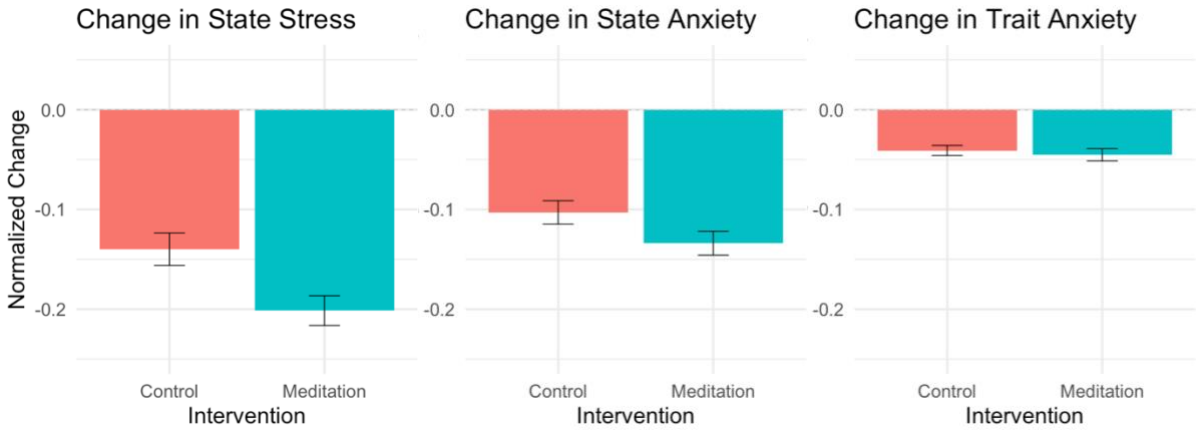


Figure 1.1 *Primary Analyses: Comparing Meditation and Control*

Note. Y-axes depict changes in normalized State Stress, State Anxiety, and Trait Anxiety from pre- to post-Intervention (post-pre/max), such that reductions in stress and anxiety indicate an improvement in well-being following a 20-minute Intervention.

Secondary Analyses: Mechanistic Role of Expectations and Thoughts

Do expectations of benefits or the valence of thought content contribute to improvements in well-being during meditation versus control? Using the same dataset, the roles of Expectation and Thoughts are assessed to better understand the relationship between meditation and improved well-being.

Prior to analyses, variables were correlated with each other to better understand the nature of the relationship between variables (i.e., to determine if moderation or mediation is possible). First, as Table 1.2 shows, the independent variable (Intervention) does not predict the Secondary Variables (Expectation, Thoughts); therefore, mediation is not possible. In other words, Expectation and Thoughts do not differ between the Meditation and Control groups. However, Expectation and Thoughts are related to the State Stress, and Primary Analyses confirm the effect of the Intervention on State Stress; therefore, model comparisons using Type III Sum of Squares will assess for potential moderation. Trait Anxiety, unsurprisingly, was correlated with State Stress ($r = 0.26$, $p = 0.0001$) and State Anxiety ($r = 0.37$, $p < 0.000$), but no other variables. It is not included in Table 1.2 or Secondary Analyses because it was not expected to change, but served as a check on demand effects.

Table 1.2

Correlation Matrix for Intervention and Primary and Secondary Variables (N = 207)

Measure	1	2	3	4
1. Intervention	---			
2. State Stress	-0.19 (0.006)**	---		
3. State Anxiety	-0.13 (0.07)	0.67 (0.00)***	---	
4. Expectation	-0.08 (0.28)	-0.12 (0.09)	-0.13 (0.06)	
5. Thoughts	-0.06 (0.38)	-0.15 (0.03)*	-0.01 (0.86)	0.2 (0.004)**

Note. Values shown are zero-order correlation Pearson's *r*-values (and corresponding *p*-values in parentheses). * $p < .05$, ** $p < .01$, *** $p < .001$.

Expectation. Expectations were measured on a 100-point slider scale, with higher values indicating belief in improvement, and lower values indicating belief in no change to well-being. Note, as no participant indicated expectation below "45", or no change, no participant expressed a belief in worsening well-being.

State Stress. An *ANCOVA* on State Stress by Intervention and Expectation (see Table 1.3) revealed a diminished effect of Intervention ($F(1, 203) = 1.94$, $p = 0.17$) as compared to the Primary Analyses, a trending of Expectation ($F(1, 203) = 3.89$, $p = 0.05$), and no interaction ($F(1, 203) = 0.72$, $p = 0.4$).

Table 1.3

Fixed-Effects ANCOVA results for Intervention (INT) and Expectation using State Stress as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\eta^2$	$_{\text{partial}}\eta^2$ [95% CI]
(Intercept)	0.03	1	0.03	1.02	.314		
INT	0.05	1	0.05	1.94	.165	.01	[.00, .05]
Expectation	0.10	1	0.10	3.89	.050	.02	[.00, .07]
INT x Expectation	0.02	1	0.02	0.72	.398	.00	[.00, .04]
Error	5.04	203	0.02				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2). * $p < .01$, ** $p < .001$, *** $p < .0001$.

State Anxiety. An *ANCOVA* on State Anxiety by Intervention and Expectation (see Table 1.4) revealed a diminished effect of Intervention ($F(1, 203) = 0.27$, $p = 0.6$) as compared to the Primary Analyses, a trending effect of Expectation ($F(1, 203) = 4.29$, $p = 0.04$), and no interaction ($F(1, 203) = 0.02$, $p = 0.9$).

Table 1.4

Fixed-Effects ANCOVA results for Intervention (INT) and Expectation using State Anxiety as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 95% CI
(Intercept)	0.01	1	0.01	0.41	.523		
INT	0.00	1	0.00	0.27	.604	.00	[.00, .03]
Expectation	0.06	1	0.06	4.29	.040	.02	[.00, .07]
INT x Expectation	0.00	1	0.00	0.02	.886	.00	[.00, .01]
Error	2.97	203	0.01				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2). * $p < .01$, ** $p < .001$, *** $p < .0001$.

When including Expectation in the model, the effect of Intervention goes away. As Figure 1.2 suggests, there may be contributing main effects of Intervention and Expectation; however, these fail to reach significance. Since Intervention appears to be independent from Expectation (see Table 1.2), mediation is unlikely. This relationship requires further study to clarify.

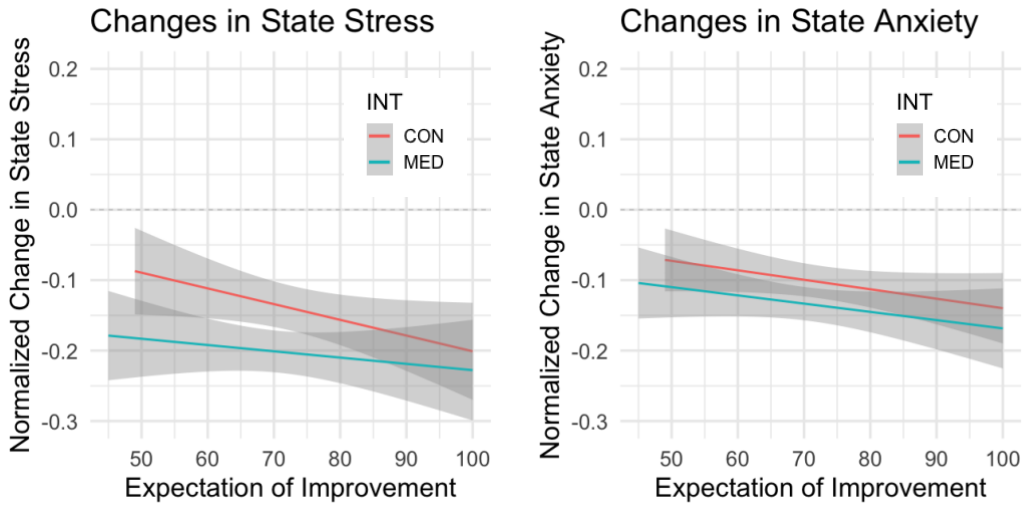


Figure 1.2 *Secondary Analyses: Expectation*

Note. Expectation ranges from 0 ("I think I will feel much worse") to 100 ("I think I will feel much better"), with a score of 50 corresponding to "I think I will feel the same." Trend lines show 95% confidence interval. INT = Intervention; CON = Control; MED. = Meditation.

Thoughts. Thought Valence was measured on a 7-point Likert scale, with higher values indicating positive thoughts, mid-range values indicating neutral thoughts, and lower values indicating negative thoughts. Note, very few participants (n = 3) indicated the lowest values (n=1, "very negative"; n=2, "negative").

State Stress. An *ANCOVA* on State Stress by Intervention and Thoughts (see Table 1.5) revealed a strengthened effect of Intervention ($F(1, 203) = 12.95$, $p = 0.0004$) as compared to the Primary Analyses, a (marginally) significant effect of Thoughts ($F(1, 203) = 8.75$, $p = 0.003$)), and a (marginally) significant interaction ($F(1, 203) = 9.03$, $p = 0.003$). The interaction between Intervention and Thoughts reveals that only those with positive thoughts improved in the Control condition, whereas everyone improved in the Meditation condition regardless of their thought valence.

Table 1.5

Fixed-Effects ANCOVA results for Intervention (INT) and Thought Valence (Thoughts) using State Stress as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 [95% CI]
(Intercept)	0.01	1	0.01	0.37	.544		
** INT	0.31	1	0.31	12.95	.000	.06	[.01, .13]
* Thoughts	0.21	1	0.21	8.75	.003	.04	[.00, .11]
* INT x Thoughts	0.21	1	0.21	9.03	.003	.04	[.01, .11]
Error	4.79	203	0.02				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2). * $p < .01$, ** $p < .001$, *** $p < .0001$.

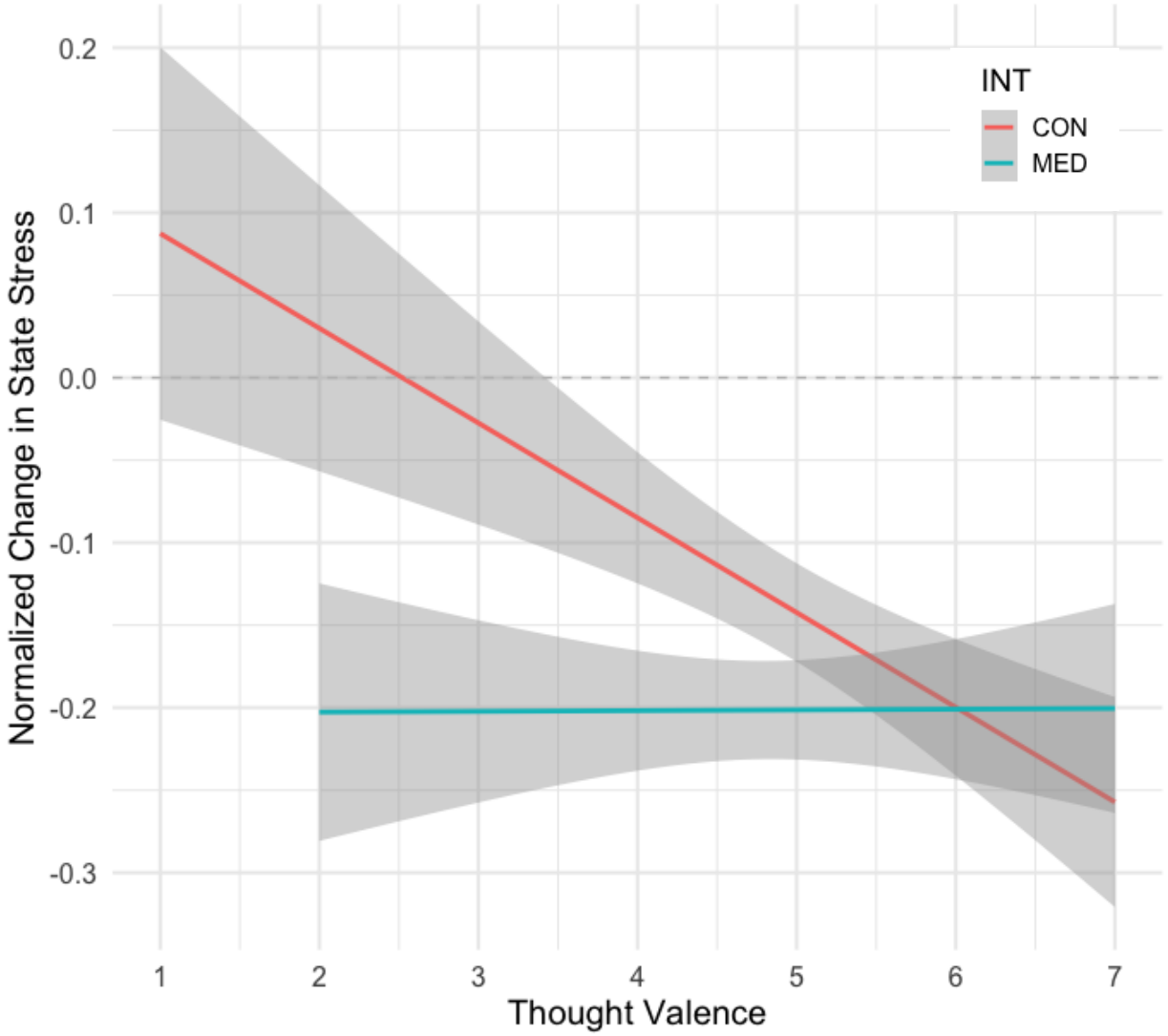


Figure 1.3 *Secondary Analyses: Thoughts and State Stress*

Note. Thought Valence ranges from 1 ("Very Negative") to 7 ("Very Positive"), with a score of 4 corresponding to "Neutral." Trend lines show 95% confidence interval. INT = Intervention; CON = Control; MED. = Meditation.

State Anxiety. An *ANCOVA* on State Anxiety by Intervention and Thoughts (see Table 1.6) revealed a strengthened effect of Intervention ($F(1, 203) = 6.74$, $p = 0.01$) as compared to the Primary Analyses, no effect of Thoughts ($F(1, 203) = 0.47$, $p = 0.5$)), and a trending interaction ($F(1, 203) = 5.02$, $p = 0.03$). However, as the 95% confidence intervals for the effect size all include zero, no strong conclusions can be drawn given this evidence. Nevertheless, as

Figure 1.4 suggests, there seems to be a similar pattern as seen in State Stress, particularly for the differential improvements for participants with negative thoughts. Those with negative thoughts in the Meditation condition had significant reductions in State Anxiety, but participants with negative thoughts in the Control condition did not.

Table 1.6

Fixed-Effects ANCOVA results for Intervention (INT) and Thought Valence (Thoughts) using State Anxiety as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\,\eta^2$	$_{\text{partial}}\,\eta^2$ [95% CI]
(Intercept)	0.09	1	0.09	5.85	.016		
* INT	0.10	1	0.10	6.74	.010	.03	[.00, .09]
Thoughts	0.01	1	0.01	0.47	.494	.00	[.00, .03]
· INT x Thoughts	0.07	1	0.07	5.02	.026	.02	[.00, .08]
Error	2.95	203	0.01				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2). * $p < .01$, ** $p < .001$, *** $p < .0001$.

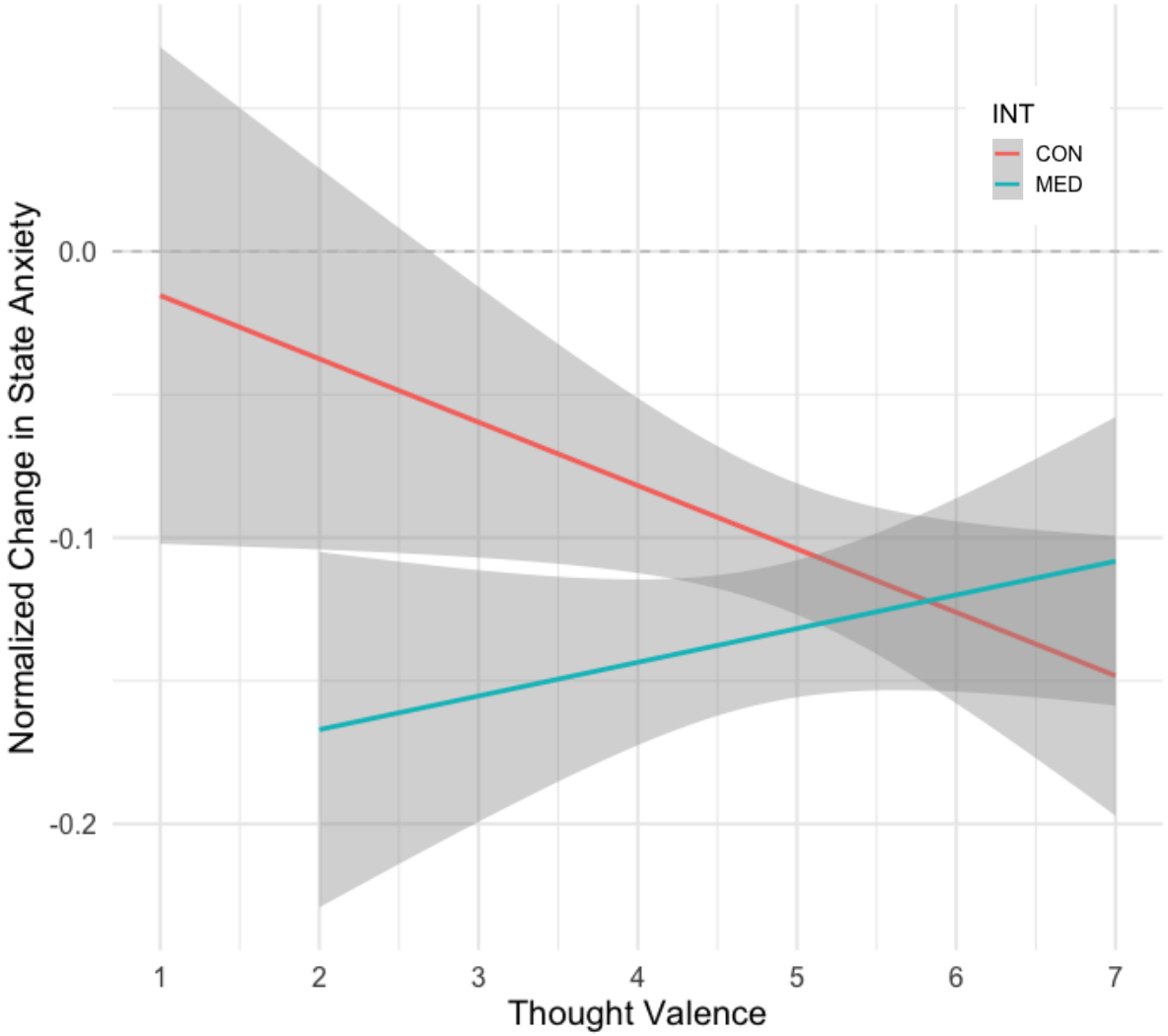


Figure 1.4 *Secondary Analyses: Thoughts and State Anxiety*

Note. Thought Valence ranges from 1 ("Very Negative") to 7 ("Very Positive"), with a score of 4 corresponding to "Neutral." Trend lines show 95% confidence interval. INT = Intervention; CON = Control; MED. = Meditation.

Conclusion

A single, 20-minute session of mindful meditation improves state well-being by about 20%, significantly more than a comparable relaxation exercise that improved well-being by about 14% (percentages are absolute, not relative). This effect was strongest for state stress and

marginal for state anxiety. We can reasonably rule out demand effects due to the fact that Trait Anxiety, a more stable measure of well-being, did not show any changes.

Secondary analyses re-examined this effect for state stress and state anxiety while considering the role of two mechanistic variables: an expectation to improve and the valence of one's thoughts. Although more research is necessary to draw any conclusions about the role of Expectation, the role of Thought valence showed significant results in relation to State Stress. The effect of Intervention becomes more significant, and Thoughts are a significant predictor of State Stress. However, more importantly, there is a significant interaction. In the Meditation condition, Thoughts have no influence on State Stress. Specifically, regardless of the thought valence, everyone in the Meditation condition had significant reductions in State Stress; whereas, in the Control condition, only participants with more positive thoughts showed similar reductions in State Stress. In other words, meditation seems to nullify the adverse effects of negative thoughts. This suggests that meditation may change the *relationship* with one's thoughts. The model shows small to medium effect sizes, the largest being for the Intervention, as it explains about 6% of the variance in State Stress. This interaction between meditation and thought valence requires replication and further exploration to determine directionality and consistency of the effect; however, this data suggests that the influence of thoughts on stress seems to change in the context of meditation. Of note, no one in the Meditation condition chose the most negative option for Thoughts; therefore, it is also possible that Meditation not only changes the *relationship* with one's thoughts, but the content or valence as well. However, this difference was not significant (see Table 1.2).

Discussion

Primary Analyses confirmed that there are observable benefits to state well-being after a single session of meditation compared to a control relaxation exercise. The Control condition was designed to mimic the Meditation condition as much as possible, without having participants practice any components of meditation. The relaxation techniques discussed in the Control condition were not possible to practice while listening to the audio recording, and the goal was to make it relaxing, but distracting enough to prevent participants from falling asleep or trying to practice the exercises. Therefore, a technique would be discussed by the narrator, after which there would be reflection questions and pauses for the participant to think about. Although participants may practice some form of mindfulness or meditation during these reflection periods, the prompts were hopefully too frequent and distracting for any practice to compare to the guided Meditation condition. One criticism is that this form of a Control condition might be too academic, and therefore stressful, rather than relaxing. However, since there were still improvements in the control condition from pre- to post-intervention, this concern isn't strongly founded.

As expected, state measures were more likely to change than trait measures, which provides confidence that these results do not reflect simple demand effects. More so, bias and prior expectations were minimized by avoiding mention of the words "meditation" or "mindfulness"; instead, both conditions were labelled to participants as "relaxation exercises" in the hopes of equalizing expectations across groups and reducing any biases associated with these popular buzz words. Indeed, measured Expectations did not differ significantly between conditions, and majority of participants failed to correctly label the exercise as "meditation" or "mindfulness" when prompted in the exit questions (Meditation: 31%, Control: 18.5%). Tertiary

Analyses (see Chapter 4) explore covariates (such as correctly labelling the exercise) that were collected with this study in order to gain insights into who might benefit most from meditation, or in what contexts meditation is most effective (e.g., knowledge that one is meditating). Here, however, the focus is on the basic effect of comparing improvements due to Meditation versus Control conditions.

This is a key first step to establishing a "dose" effect size, comparable to the effect of repeated practice on more stable measures of well-being. Then, we can re-examine this effect in relation to potential mechanistic variables to gain better insight into the mechanisms of improvement. By better understanding how a single session of meditation improves well-being, we can more accurately investigate mechanistic questions in long-term studies in the future and build a theoretical framework based on key processes of mindfulness. While meditation and mindfulness take practice, practitioners will agree that there is power in the practice itself, and perfecting or mastering meditation is not the goal. Therefore, what insights can we gain about how this practice shifts our well-being, both in the moment and more permanently over time?

This study investigated two potential variables, expectations and thought valence, that were hypothesized to contribute to improved well-being in the context of meditation. First, it has been shown in many situations that an expectation of improvement alone can cause actual improvements (i.e., the placebo effect) (Harrington, 1999; Price et al., 2008). Most meditation studies to date fail to address this, and results that do not take expectations into account may be inflated effects. This is another motivation for structuring the analyses as they are, to see how results change when taking these variables into account. Our results show that Expectation diminished the effect of Intervention when included in the model; however, Expectation failed to reach significance. From the graph (see Figure 1.2), it looks as if there may be trending main

effects of Intervention and Expectation, such that Meditation improved more than Control, and higher Expectations were associated with greater improvements. However, as no effects reached significance, further study is necessary to draw any conclusions.

Thought valence, on the other hand, strengthened the effect of Intervention and revealed an interaction. Pre-registered predictions outlined two potential outcomes based on whether thoughts differed between the Meditation and Control conditions. If there was a benefit to meditating (over and beyond the Control condition), concomitant with the Control condition reporting more negative thoughts than the Meditation condition, then this would have been evidence that mindful meditation mitigates the *amount* of negative thinking. Instead, the second prediction appears to be true: if there was a benefit to meditation (over and beyond the Control condition, which the Primary Analyses confirmed), yet the Meditation and Control conditions report the same amount of negative thoughts, then this is evidence that mindful meditation changes one's *attachment* or *reaction* to negative thinking. Indeed, this is clear in the interaction between Thoughts and Intervention. Despite negative thoughts, participants in the Meditation condition improved just as much as participants with positive thoughts. Consistent with previous literature and the results from this study's Control condition, thoughts seem to have a powerful influence over our well-being. If altering the content of our thoughts is not always possible, then perhaps meditation can offer a way to create a more beneficial relationship with our thoughts, or to inhibit their negative influences.

Little research has looked at these variables in conjunction with meditation; therefore, it is important to ask these questions independently in order to gain better insights into the possible directionality of the relationships. Then, we can explore full model comparisons to gain insights into how to study these concepts further. In the full model, secondary variables may correct for

each other (see exploratory analyses in Chapter 4). First, however, we aimed to replicate these effects in Chapter 2, but with new conditions that compare components of meditation more directly, and to see how these internal states interact more specifically with components of meditation.

Chapters 1, 2, 3, and 4 are currently being prepared for submission for publication of the material. Bondi, Taylor E.; Dobkins, Karen. The dissertation author was the primary investigator and author of this material.

Chapter 2: Components of Meditation

Introduction

Mindfulness meditation incorporates physical and mental components that all have potential to individually reduce stress and improve well-being. Are these components sufficient in isolation? Or do they need to be practiced in conjunction in order to produce benefits in well-being? If one considers meditation the practice of mindfulness, then which components of this practice are the driving forces of improving well-being? Although this study is non-exhaustive, several components of meditation were isolated in order to gain insight into the mechanisms of improving mental health. These components of meditation are: (1) slow breathing, (2) meta-awareness, and (3) detachment, or letting go of thoughts without judgement.

Slow breathing may be sufficient, without the mental practice of mindfulness, to reduce stress. Slow breathing engages the parasympathetic nervous system, which not only relaxes the body but also maintains balance of the autonomic nervous system to improve cardiovascular and respiratory health (Jerath et al., 2006; Oneda et al., 2010; Russo et al., 2017; Zaccaro et al., 2018). Aside from health benefits, slow breathing has also been shown to increase pain tolerance thresholds, reduce negative feelings, and improve mood (Busch et al., 2012). Several studies show benefits of slow breathing on stress and well-being (Epe et al., 2021; Peterson et al., 2017); however, little research has isolated the effects of slow breathing from mindfulness in relation to non-physiological outcomes.

Meta-awareness is the awareness of or observing of one's own mind. A state of meta-awareness is actively observing one's own thoughts, and perhaps emotions, by shifting one's attention inward. In a sense, the object of attention is awareness itself. Some theorize that meta-awareness is a skill that takes time to develop, and the development of meta-awareness is a key

shift in mindfulness practitioners from novice to experienced (Vago & David, 2012). Perhaps because the development of meta-awareness must also be accompanied by the practice of non-reaction and non-judgement, meta-awareness alone may not be beneficial for the novice meditator. Meta-awareness is often studied in relation to mind-wandering and is often integral to meditation theories; however, there is little empirical evidence linking or isolating these constructs. Several studies have shown that negative mood is associated with mind-wandering (Dobkins & Guo, 2020; Killingsworth & Gilbert, 2010), and that depressive symptoms are correlated with mind-wandering without meta-awareness (Deng et al., 2014; Nayda & Takarangi, 2021). And meta-awareness is a key component in theories of mindfulness mechanisms (Vago & David, 2012). This all suggests that meta-awareness plays a key role in emotion regulation, but little is known about how or whether this takes time to develop. How might isolating a state of meta-awareness reveal the role of self-awareness in modulating momentary well-being? Observation of thoughts is one thing, but learning to let go of those thoughts without judgement or reaction is another.

Detachment, or letting go of one's thoughts without reaction, judgement, or attachment, is a key component of mindfulness and often the most difficult practice to do consistently. As Frewen and colleagues (2008) have shown, mindful meditation decreases the frequency and perception of difficulty in letting go of negative automatic thoughts. However, little research has isolated this component of meditation, or asked what role it plays in mechanisms of improvement. Perhaps this component is only effective in the presence of negative thoughts, or detachment is only effective if attention is re-oriented to something else (e.g., the breath).

These components of meditation may also interact differently with internal states. For example, perhaps slow breathing is sufficient to reduce stress, but only if the person is not

experiencing negative thoughts. Or observing one's thoughts may reduce stress, but only if they are positive. By comparing not only isolated components of meditation, but also how they relate to thought valence and expectations, we can better understand the underlying mechanisms of meditation efficacy for improved well-being. Specifically, Chapter 2 aims to (a) compare components of meditation to assess which are necessary or sufficient to improve state well-being, and to (b) ask whether these improvements are/are not influenced by participants' expectation of improvements and/or thought valence.

Methods

This study followed the same design protocol as the study presented in Chapter 1, the only difference being three additional Intervention conditions. Please see Methods in Chapter 1 for details on measurements and protocols.

Using the same Meditation and Control conditions that were used in the study discussed in Chapter 1, three additional conditions were created for this study to isolate components of meditation: (1) slow breathing, (2) meta-awareness, and (3) detachment. If we consider these three components as essential to mindful meditation, or at least included in our Meditation intervention, then which is driving improvements in well-being?

Participants were randomly assigned to one of five 20-minute "relaxation exercises," all voiced by the same narrator and matched closely for word count and timing. If there are observable benefits of a single session of meditation, which of these components is the driving mechanism, or are all required in order to improve well-being? Therefore, Meditation will be compared to the Breath Intervention, which has slow breathing without any instructions to bring awareness or attention to anything. If there are similar improvements in both conditions, it would be evidence that slow breathing is sufficient for improvements in state well-being. The

Meditation Intervention will also be compared to the Mind Intervention, which has instructions to bring awareness and attention to one's own thoughts without any instructions or reminders of slow breathing, and without instructions to let thoughts go or to not react or attach to them. If there are similar improvements in both conditions, it would be evidence that meta-awareness, or awareness of and attending to one's own mind, is sufficient for improving well-being. And if both show less improvements than Meditation, it would be evidence that the combination of these components is necessary for improved well-being. However, to test this more directly, Meditation will also be compared to the Detachment Intervention, which has instructions to bring awareness and attention to one's own mind and to acknowledge passing thoughts with compassion and let them go without judgement, but without any instructions for slow breathing or to orient attention to something (e.g., the breath). If there are similar improvements in both conditions, it would be evidence that meta-awareness and non-attachment are sufficient for improving well-being.

More concretely, are there any benefits to well-being after 20 minutes of mindful meditation compared to 20 minutes of breathing or sitting with your own thoughts? Does breathing or sitting with your own thoughts still lead to greater improvements in well-being than listening to information about relaxation techniques?

Interventions

Meditation Intervention. [slow breathing, meta-awareness, detachment]. See Chapter 1.

Control Intervention. [~~slow breathing~~, ~~meta-awareness~~, ~~detachment~~]. See Chapter 1.

Breath Intervention. [slow breathing, ~~meta-awareness~~, ~~detachment~~]. Participants were guided through a 20-minute breathing exercise. Everything was the same as in the Meditation condition, except that the instructions were to "take deep breaths", rather than focus on the

breath or let go of passing thoughts. Here, participants were asked to breathe, but were not instructed to do anything with their thoughts and did not receive any instructions that brought awareness to their breath or thoughts. This controls for the physical practice of slow breathing without having participants actually learn or practice mindfulness. In other words, this condition matches all components in the mindful meditation condition except active awareness or control of one's own thoughts.

Mind Intervention. [~~slow breathing~~, meta-awareness, ~~detachment~~]. Participants were asked to sit silently with their thoughts for 20 minutes, without any instructions for slow breathing. In this condition, everything was the same as in the Meditation condition, except that the instructions were to "pay attention to your thoughts, and let your mind wander wherever it wants to go". Here, participants were asked to bring their awareness to their thoughts and sustain it, rather than let go of the thoughts without judgement. This controls for being aware of one's own thoughts, without having participants actually learning to meditate or practice detachment (e.g., to let go of those thoughts without reaction or judgement).

Detachment Intervention. [~~slow breathing~~, meta-awareness, detachment]. Participants were asked to sit silently with their thoughts for 20 minutes, and to let those thoughts pass without judgement, but without any instructions for slow breathing. In this condition, everything was the same as in the Mind condition, except that the instructions were to "let go of your thoughts without judgement". Here, participants were asked to bring their awareness to their thoughts and let them go, rather than sustaining the thoughts. This controls for being aware of one's own thoughts and to let them go (meta-awareness + detachment) without any instructions about breath or to reorient one's attention. Of note, it is impossible to isolate "detachment" from "meta-awareness" due to the fact that one cannot let go of a thought without first being aware of

it. However, this intervention still offers a comparison to the role of slow breathing and focusing on the breath.

Analysis Plan

Because little research has been done in the context of such a short time-frame, and nearly no research has compared isolated components of meditation nor investigated the mechanistic role of these "internal state" variables, it is important to first establish the simple effect. Therefore, Primary Analyses ask if there is a difference in a change in well-being between participants in each of the five conditions. (Pre-registered) predictions include greater improvements in well-being in the Meditation condition compared to Control, and more improvement in the state, not trait, measures of well-being. Additionally, the three Component Interventions are expected to do better than Control, with the Breath Intervention the most likely to show similar improvements to the Meditation. Then, Secondary Analyses address the role of expectation and thought valence, to ask whether these internal states explain improvements in well-being seen in the Primary Analyses.

The following analyses will use a Bonferroni familywise error rate correction. Based on 21 planned tests (in Chapters 1, 2 and 3), the alpha value of $p = 0.05$ will be adjusted to a critical value of $p = 0.002$ for each individual test.

Results

Preliminary Analyses

Exclusions. Data collection continued until, after running the inclusion criteria code, there was a minimum of 500 participants (100 per condition). However, due to an error in the randomizer, data was over-collected for some conditions and under-collected for others. In order to minimize deviations from the pre-registration, it was decided to continue data collection until

all conditions had 100 participants, and exclude data collected after this cap was reached based on participation date. Data was collected from a total of *N*=1755 participants. Consecutively, *n*=78 participants were removed for not finishing the study, *n*=72 were removed for failing more than one attention check, *n*=178 were removed for failing the subjective general engagement question, *n*=209 were removed for failing the survey subjective validity question, and *n*=532 were removed for failing the intervention subjective validity question. To reduce the number of participants to the pre-registered goal of 100 participants per condition in order to address the randomization error, *n*=186 were removed based on participation date. Therefore, the final sample of *N*=500 (*n*=100 participants in each condition) participants very likely gave their full effort and attention to participating. See *Inclusion Criteria* (Chapter 1), for details on these items.

Demographics. This study had a sample of *N*=500 undergraduate students, with a mean age of 20.8 years (with a SD of 3.4 years). There were 338 (68%) who identified as female, 153 (31%) who identified as male, 4 (1%) who identified as Nonbinary, and 5 (1%) who preferred not to say. There were 202 (40%) students who identified as Asian, 134 (27%) as Hispanic or Latino, 87 (17%) as White, 5 (1%) as Black or African American, 23 (5%) as Middle Eastern or North African, 3 (<1%) as Native Hawaiian or Pacific Islander, 37 (7%) as Mixed, and 9 (2%) preferred not to answer. There were 91 (18%) Freshman, 110 (22%) Sophomores, 154 (31%) Juniors, 134 (27%) Seniors, and 11 (2%) Fifth years.

Primary Analyses: Comparing Components of Meditation

Are there any benefits to well-being after 20 minutes of mindful meditation compared to an informational control exercise, a slow breathing exercise, a meta-awareness exercise and or a detachment exercise? Normalized difference scores, indicating absolute percent change from before to after the 20-minute Intervention, were calculated for the three measures of well-being: State Stress (SS), State Anxiety (SA), and Trait Anxiety (TA). These were calculated by subtracting the post-Intervention scores from the pre-Intervention scores, and dividing by the difference by the maximum score of the scale (post-pre/max). Note that pre-scores for each of these measures did not differ between the Meditation and Control conditions (SS: $F(4,495) = 2.01$, $p = 0.1$; SA: $F(4,495) = 1.80$, $p = 0.1$; TA: $F(4,495) = 0.52$, $p = 0.7$).

A one-way ANOVA comparing improvement in well-being by Intervention (Meditation, Control, Breath, Mind, Detachment) for each of the three outcome measures revealed a significant effect of Intervention on change in State Stress ($F(4, 495) = 4.98$, $p = 0.0006$), a significant effect on State Anxiety ($F(4, 495) = 4.87$, $p = 0.0007$), and, as expected, no effect on Trait Anxiety ($F(4, 495) = 0.79$, $p = 0.5$). Looking at the pairwise comparisons, using TukeyHSD and a 95% family-wise confidence level, the differences between conditions can be explored (note: post-hoc tests were not included in the pre-registered tests / Bonferroni alpha adjustment, significance language based on alpha=0.05). The Breath Intervention had the biggest reductions in State Stress, and was not different from the Meditation ($p = 0.9$). The Breath Intervention reduced State Stress more than the Control, Mind, and Detachment Interventions ($p = 0.02$, $p = 0.003$, $p = 0.02$, respectively). However, the Meditation Intervention was not significantly different from any condition. This pattern of results was consistent for State Anxiety as well. This provides evidence that taking slow, deep breaths for 20 minutes is a more

effective “relaxation exercise” than 20 minutes of noticing thoughts, letting go of thoughts, or listening to an informational exercise, and equally effective as a meditation.

Table 2.1

Means, Standard Errors, and Effect Sizes (Eta-Squared) of Change in State Stress, State Anxiety, and Trait Anxiety for Meditation (MED), Control (CON), Breath (BTH), Mind (MND), and Detachment (DET) Conditions (N=500)

Measure	*Mean [Standard Error]*					Eta Squared [95% Confidence Interval]
	CON	*MED*	BTH	MND	DET	
State Stress	-0.17 [0.02]	-0.21 [0.02]	-0.23 [0.01]	-0.16 [0.01]	-0.17 [0.02]	0.04 [0.01, 0.06]
State Anxiety	-0.09 [0.01]	-0.13 [0.01]	-0.15 [0.01]	-0.10 [0.01]	-0.10 [0.01]	0.04 [0.01, 0.06]
Trait Anxiety	-0.03 [0.01]	-0.04 [0.01]	-0.04 [0.01]	-0.03 [0.01]	-0.03 [0.01]	*NA*

Note. Means indicate normalized difference scores from pre- to post-intervention. Effect size for Trait Anxiety was not calculated because there was not a significant effect. For eta squared, a small effect is 0.01, medium is 0.06, and large is 0.14. * $p < .01$, ** $p < .001$, *** $p < .0001$.

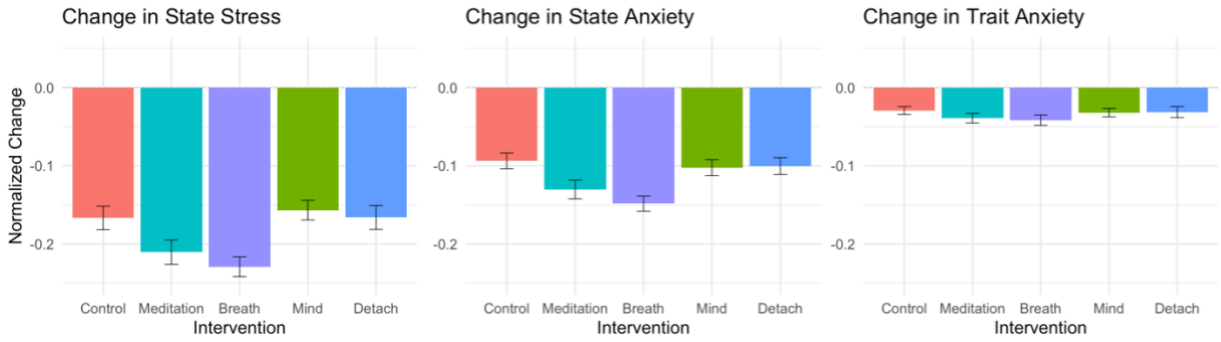


Figure 2.1 *Primary Analyses: Comparing Components of Meditation*

Note. Y-axes depict changes in normalized State Stress, State Anxiety, and Trait Anxiety from pre- to post-Intervention (post-pre/max), such that reductions in stress and anxiety indicate an improvement in well-being following a 20-minute Intervention.

Secondary Analyses: Mechanistic Role of Expectations and Thoughts

Do expectations of benefits or the valence of thought content contribute to improvements in well-being during meditation versus control or while practicing a single component of meditation? Using the same dataset as the Primary Analyses above, the roles of Expectation and Thoughts are assessed to better understand the relationship between meditation and improved well-being.

Expectation. Expectations were measured on a 100-point slider scale, with higher values indicating belief in improvement, middle values indicating belief in no change to well-being, and low values indicating a belief in worsening well-being. Expectation scores did not use the entire possible range, but ranged from a score of 21 to 100. Mean Expectation scores did not differ by condition ($F(4, 495) = 0.83$, $p = 0.5$).

State Stress. An *ANCOVA* on State Stress by Intervention and Expectation (see Table 2.2) revealed a diminished effect of Intervention ($F(4, 490) = 1.40$, $p = 0.2$) as compared to the Primary Analyses, a significant effect of Expectation ($F(1, 490) = 20.73$, $p < 0.000$), and no interaction ($F(4, 490) = 1.71$, $p = 0.15$).

Table 2.2

Fixed-Effects ANCOVA results for Intervention (INT) and Expectation using State Stress as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 [95% CI]
(Intercept)	0.05	1	0.05	2.63	.106		
INT	0.11	4	0.03	1.40	.233	.01	[.00, .03]
*** Expectation	0.41	1	0.41	20.73	.000	.04	[.01, .08]
INT x Expectation	0.13	4	0.03	1.71	.147	.01	[.00, .03]
Error	9.57	490	0.02				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2). * $p < .01$, ** $p < .001$, *** $p < .0001$.

State Anxiety. An *ANCOVA* on State Anxiety by Intervention and Expectation (see Table 2.3) yielded similar results to State Anxiety, with a diminished effect of Intervention ($F(4, 490) = 1.56$, $p = 0.2$) as compared to the Primary Analyses, a trending effect of Expectation ($F(1, 490) = 6.42$, $p = 0.01$), and no interaction ($F(4, 490) = 2.01$, $p = 0.1$).

Table 2.3

Fixed-Effects ANCOVA results for Intervention (INT) and Expectation using State Anxiety as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\ \eta^2$	$_{\text{partial}}\ \eta^2$ [95% CI]
(Intercept)	0.07	1	0.07	6.44	.011		
INT	0.07	4	0.02	1.56	.183	.01	[.00, .03]
* Expectation	0.07	1	0.07	6.42	.012	.01	[.00, .04]
INT x Expectation	0.09	4	0.02	2.01	.092	.02	[.00, .04]
Error	5.36	490	0.01				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2). * $p < .01$, ** $p < .001$, *** $p < .0001$.

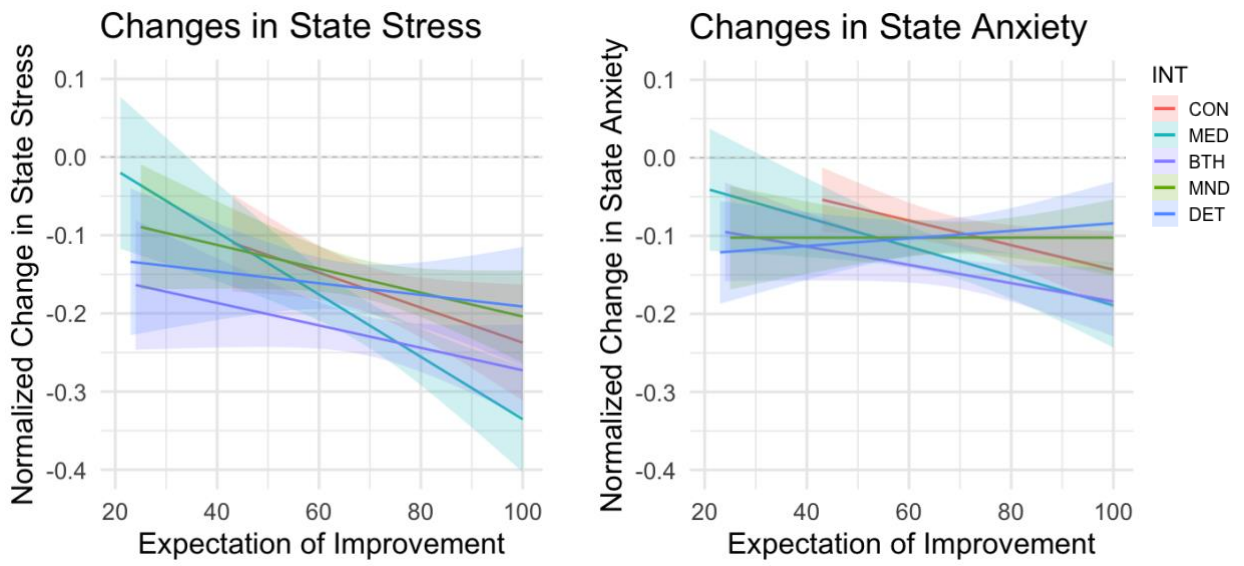


Figure 2.2 *Secondary Analyses: Expectation*

Note. Expectation ranges from 0 ("I think I will feel much worse") to 100 ("I think I will feel much better"), with a score of 50 corresponding to "I think I will feel the same." Trend lines show 95% confidence interval. INT = Intervention; CON = Control; MED. = Meditation; BTH = Breath; MND = Mind; DET = Detachment.

Including Expectation in the models nullifies the effect of Intervention, suggesting that Expectation explains more variance in changes in State Stress and State Anxiety than Intervention. Mediation is unlikely because Intervention and Expectation are unrelated. In other words, Intervention does not predict Expectation, a necessary link for mediation. Moderation is also unlikely because the interaction is not significant. In other words, there is not a differential effect of Expectation on changes in State Stress or State Anxiety depending on the Intervention. Therefore, Expectation is a third variable that strongly predicts changes in State Stress and State Anxiety, above and beyond the effect of Intervention.

Thoughts. Thought Valence was measured on a 7-point Likert scale, with higher values indicating positive thoughts, lower values indicating negative thoughts, and mid-range values indicating neutral thoughts. Mean Thoughts scores did not differ by condition ($F(4, 495) = 1.19$, $p = 0.3$).

State Stress. An *ANCOVA* on State Stress by Intervention and Thoughts (see Table 2.4) revealed a diminished effect of Intervention ($F(4, 490) = 0.73$, $p = 0.6$) as compared to the Primary Analyses, a trending effect of Thoughts ($F(1, 490) = 3.68$, $p = 0.06$)), and no interaction ($F(4, 490) = 0.80$, $p = 0.5$).

Table 2.4

Fixed-Effects ANCOVA results for Intervention (INT) and Thought Valence (Thoughts) using State Stress as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\,\eta^2$	$_{\text{partial}}\,\eta^2$ [95% CI]
(Intercept)	0.56	1	0.56	27.31	.000		
INT	0.06	4	0.01	0.73	.571	.01	[.00, .02]
Thoughts	0.08	1	0.08	3.68	.056	.01	[.00, .03]
INT x Thoughts	0.07	4	0.02	0.80	.526	.01	[.00, .02]
Error	9.99	490	0.02				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2).

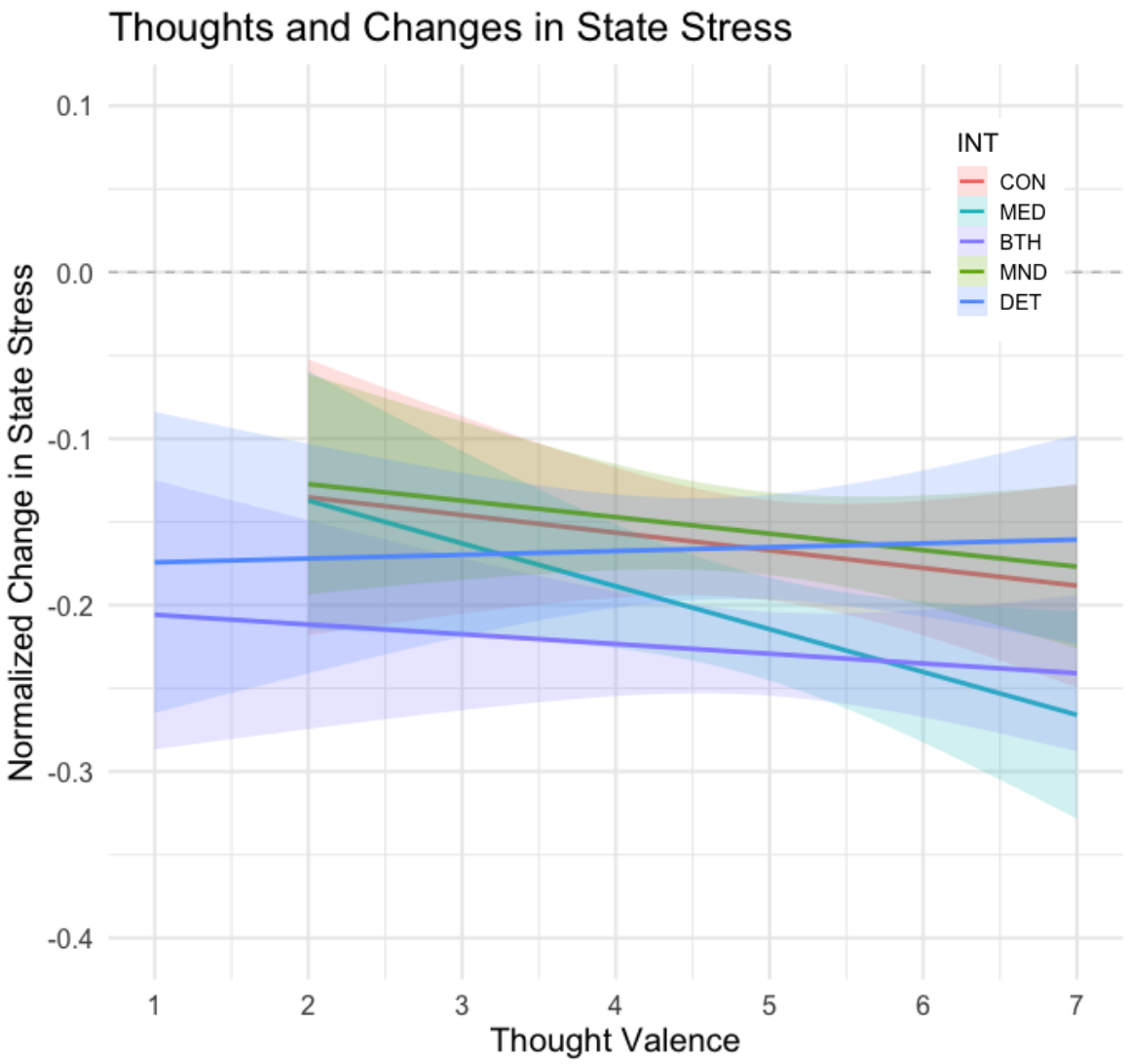


Figure 2.3 *Secondary Analyses: Thoughts and State Stress*

Note. Thought Valence ranges from 1 ("Very Negative") to 7 ("Very Positive"), with a score of 4 corresponding to "Neutral." Trend lines show 95% confidence interval. INT = Intervention; CON = Control; MED. = Meditation; BTH = Breath; MND = Mind; DET = Detachment.

State Anxiety. An *ANCOVA* on State Anxiety by Intervention and Thoughts (see Table 2.5) revealed a diminished effect of Intervention ($F(4, 490) = 0.24$, $p = 0.9$) as compared to the Primary Analyses, no effect of Thoughts ($F(1, 490) = 1.98$, $p = 0.2$)), and no interaction ($F(4, 490) = 0.48$, $p = 0.8$).

Table 2.5

Fixed-Effects ANCOVA results for Intervention (INT) and Thought Valence (Thoughts) using State Anxiety as the criterion.

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\,\eta^2$	$_{\text{partial}}\,\eta^2$ [95% CI]
(Intercept)	0.23	1	0.23	20.87	.000		
INT	0.01	4	0.00	0.24	.917	.00	[.00, .01]
Thoughts	0.02	1	0.02	1.98	.160	.00	[.00, .02]
INT x Thoughts	0.02	4	0.01	0.48	.750	.00	[.00, .01]
Error	5.47	490	0.01				

Note. For partial eta-squared, a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared (η^2).

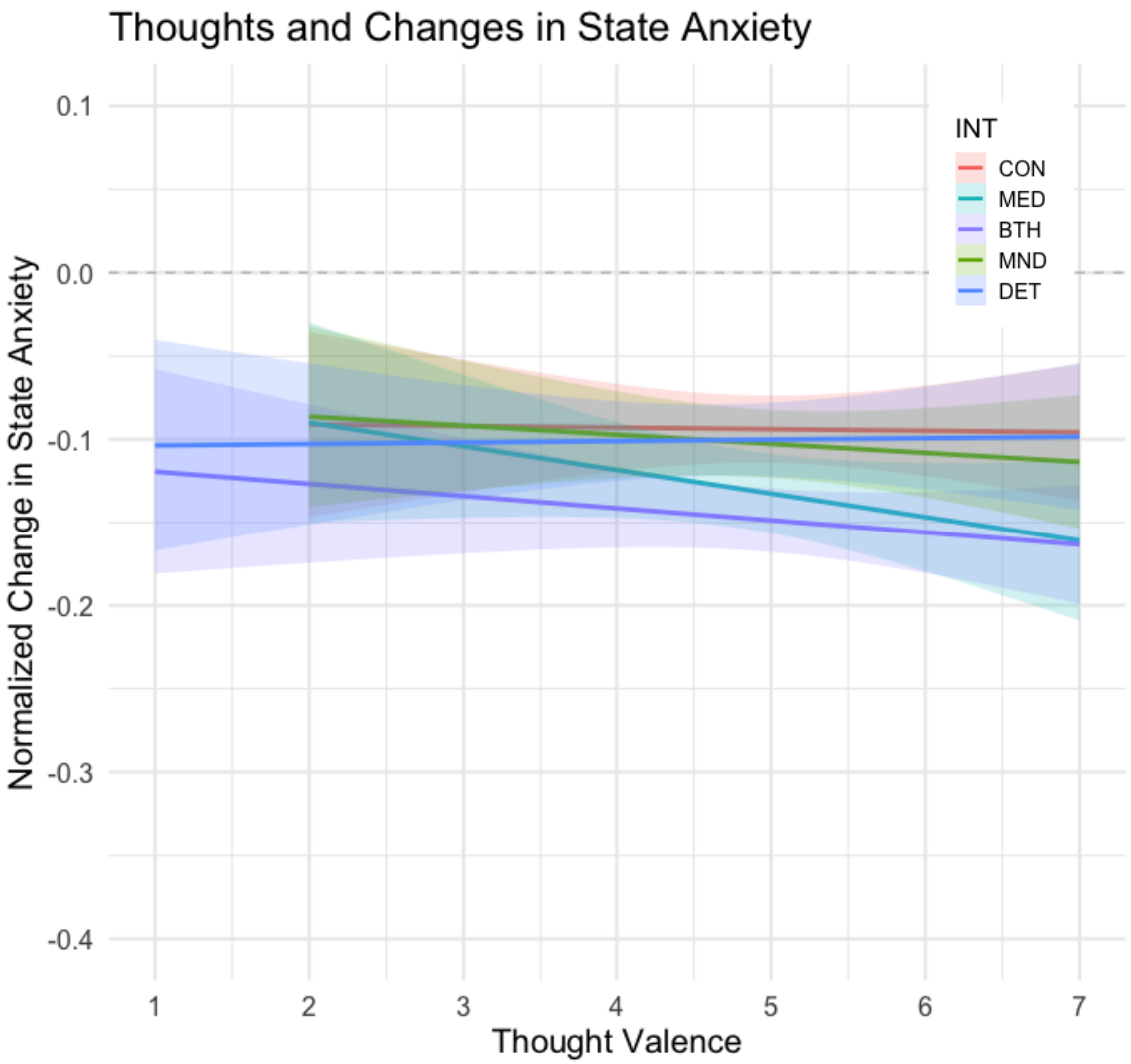


Figure 2.4 *Secondary Analyses: Thoughts and State Anxiety*

Note. Thought Valence ranges from 1 ("Very Negative") to 7 ("Very Positive"), with a score of 4 corresponding to "Neutral." Trend lines show 95% confidence interval. INT = Intervention; CON = Control; MED. = Meditation; BTH = Breath; MND = Mind; DET = Detachment.

Conclusion

Results from the primary analyses, comparing Meditation to isolated components of meditation (breath, meta-awareness, and detachment) and a control condition, found improvements in well-being in in all conditions, with the Breath Intervention showing the biggest reductions in State Stress and State Anxiety. The Breath Intervention reduced stress and

anxiety significantly more than the Control, Mind, and Detachment Interventions, but not the Meditation Intervention. However, the Meditation Intervention did not reduce stress significantly more (or less) than any other Intervention.

Secondary analyses re-examined these effects for state stress and state anxiety while considering the role of two mechanistic variables: expectations and thought valence. Expectation and Thoughts both nullified the effect of Intervention; however, only Expectation significantly predicted change in State Stress and State Anxiety. Participants that expected to improve more had larger reductions in State Stress, and participants that expected to feel worse had smaller reductions in State Stress. This effect was consistent but less strong for State Anxiety. While mediation or moderation are unlikely, Expectation seems to be a third variable that explains change in well-being above and beyond the Intervention. Thoughts neither predicted change in State Stress or State Anxiety nor interacted with Intervention, failing to replicate the results from Chapter 1.

Discussion

These results do not replicate the results from Chapter 1. Meditation was no longer significantly different from Control, and the interaction with Thoughts was no longer present. Furthermore, Meditation did not differ from any Intervention that isolated a specific component of meditation, against hypothesized predictions. Failure to replicate the effect of Intervention may be partially explained by the improvements in well-being seen in the Control condition, which had similar improvements as the other Interventions. The Control condition may have been too relaxing to be a strong enough comparison to the meditation in the context of a single session of practice. Perhaps differences would arise with repeated practice over several days, but for a single session, meditation is similarly beneficial to generic relaxation exercises. Future

research may need to implement a longer period of practice in order to differentiate the effects of breath, meta-awareness, and detachment.

Expectations seem to play an important role in how likely or how much a person is to benefit from a relaxation exercise. These results provide evidence in support of measuring, equating, or at least accounting for expectations in treatment or intervention studies. Mediation may be a possible explanation if expectations differ by treatment group; however, expectations were similar across conditions in the present study. While mediation is not possible, expectations nonetheless nullified the effect of Intervention when included in the model, suggesting that one's expectations are the strongest predictor of change in well-being. One concern is that expectations may be inflated, and do not reflect actual expectations if they had remained unprompted. However, expectations are measured in all conditions, and this study was most interested in the mechanistic role of expectations rather than measuring absolute expectations.

When considering the role of thought valence, it was surprising that the interaction with Intervention found in Chapter 1 did not replicate. While Chapter 1 showed that participants with negative thoughts only improved in well-being if they were in the Meditation Intervention, and not the Control Intervention, the present study showed improvements in well-being in all conditions regardless of thought valence. Negative thoughts were no longer associated with less improvements, and positive thoughts did not predict more improvement than those with negative thoughts. In other words, there was no relationship between the valence of one's thoughts and how much change in state stress and state anxiety they showed in any condition. This is especially surprising for the Mind Intervention, which had participants focus on their thoughts without any instructions to let them go or detach from them. It is surprising, therefore, that participants with negative thoughts in this condition still showed reductions in stress. Despite

failure to replicate the results of Chapter 1, future research may consider the role of thoughts in contemplative practices.

Chapters 1, 2, 3, and 4 are currently being prepared for submission for publication of the material. Bondi, Taylor E.; Dobkins, Karen. The dissertation author was the primary investigator and author of this material.

Chapter 3: Label Bias & Placebo Effects

Introduction

Chapter 1 established observable benefits to state well-being from a single session of meditation, and revealed that meditation may negate the detrimental effects of negative thoughts. Chapter 2 revealed that slow breathing is an important component that drives improvements in well-being in the context of a single session of meditation, and expectations play an important role in how much a person improves from a guided exercise. Now, with a better understanding of key components and underlying mechanisms, the present study aimed to further explore the role of expectation in meditation. By comparing benefits from the same meditation intervention presented in different ways, various contextual factors that increase expectations (and therefore contribute to a placebo effect) may be isolated. Specifically, Chapter 3 investigates the placebo effect by manipulating two potential sources of inflated expectations: label bias and the demand effects. Label bias is a belief in a label, such that one will have greater expectations of improvement when the exercise is labelled as a "meditation" as compared to a "relaxation exercise." Demand effects are a belief that one is supposed to improve, such that one will have greater expectations of improvement when a researcher indicates expected benefits versus giving no indications. Both of these may inflate expectations of improvement as well as actual improvements, thus contributing to a placebo effect.

The placebo effect is when a participant exhibits observable/measurable improvements from a null manipulation. In other words, the belief in benefits or expectation of improvement causes actual improvement. The placebo effect has been studied extensively in many disciplines and is considered to be a well-established phenomenon (Harrington, 1999). Recently, the conceptualization of the placebo effect has broadened (Price et al., 2008) from a null

manipulation (e.g., a sugar pill) to any simulation of treatment (e.g., filling out a survey before and after an intervention).

In meditation research, the placebo effect is likely an important underlying mechanism that needs further study (Farb et al., 2012). The placebo effect is induced by participant expectations (Petrovic et al., 2005), and may explain or modulate meditation benefits (Prätzlich et al., 2016). While there are many potential sources within a meditation study that might increase participants' expectations, label bias and demand effects were chosen as particularly relevant to meditation. The label bias has not been directly tested. As Shonin and colleagues (2015) point out, this "popularity effect" associated with the label of meditation is difficult to isolate because it is hard to blind participants to the knowledge that they are meditating if they have experience with mindfulness techniques. For this same reason, it is also difficult to equate demand effects, which would require creating conditions that induce equal expectations in participants. One approach is to recruit novice meditators and tell all participants that they are meditating, while only some actually meditate (and the others believe they are meditating but are not taught mindfulness techniques). This approach was designed by Fadel and colleagues (2010; 2015), who found improvements in mood, cardiovascular health, and pain relief from meditation, above and beyond placebo effects. In other words, by equating the label, they could rule out label bias, and by equating the context in which the intervention was presented and taught, they could rule out demand effects. Alternatively, the present study guides all participants through the same meditation, but only some are told that it is a meditation. While the approach Fadel and colleagues designed equates expectations across different interventions in order to isolate the unique effect of meditation, the current study equates the intervention across different contexts in order to isolate the unique effect of expectations.

The goal of this study was to better understand the role of expectations by manipulating them across the same intervention. Specifically, what role does the label of meditation, or a belief that one should improve, play in actual changes in well-being following a meditation? By both manipulating and measuring expectations, the roles of these sources of increased expectations may be better understood and accounted for.

Methods

Chapters 1 and 2 measured expectations in order to determine whether it moderated or mediated improvement in well-being. Now, Chapter 3 asks what causal influence expectations might have. Using only the Meditation Intervention and continuing to measure expectations (as a covariate as well as a manipulation check), this stage also manipulates expectations in two ways: with a placebo statement and with a meditation label.

Expectations about improvement in well-being due to meditation likely arise in two ways, both of which occur frequently in previous meditation research. The first is a general treatment, or demand effect, where participants expect to improve because the researcher, scientist, doctor, or peers expect improvement. This demand effect will be targeted by implementing a placebo statement to half of the participants, telling them that they *should* feel better after the exercise. The second way expectations may arise in participants is by simply seeing the word, or label, of "meditation." There are likely strong biases associated with the label, which has become a buzz word in Western society, and presenting participants with the knowledge that they are participating in a "meditation study" will likely trigger additional expectations. Therefore, half the participants are told that they will participate in a meditation, while the other half are told that they will participate in a "relaxation exercise." Isolating these two potential ways of increasing expectations of improvement will provide a better

understanding about whether inflated results might be associated with a general treatment effect, or something more specific to mindfulness and meditation.

Conditions

All participants listened to the same 20-minute audio recording of a mindful meditation, which is identical to the Meditation Intervention used in Chapters 1 and 2 (see Chapter 1 for details). Therefore, this chapter will replace the word "Intervention" with "Condition" because whereas Chapters 1 and 2 used different Interventions, Chapter 3 used one Intervention, but the Conditions differ by the information presented to participants. [i.e., for consistency across chapters, the term "Intervention" refers to the recording used, which also translates to the conditions of Chapters 1 and 2. Here, however, Intervention still refers to the recording used, and Condition refers to the framing, or context information, that creates the comparison Conditions of the study and are described below].

The differing information for each Condition is presented to participants in the middle of the study, after filling out pre-questionnaires and immediately prior to participation in the "relaxation exercise", as the Intervention is referred to in the recruitment study title, information, and consent form. Following a 2x2 between-subjects design (see Table 3.1), half of the participants read a Placebo Statement (P), and half the participants received no additional statement (nP); additionally, half the participants were provided with the label "meditation" for the exercise (L), and half were only told that it was a "relaxation exercise" (nL).

Table 3.1

Conditions

Label, Placebo (L/P)	Label, No Placebo (L/nP)
No Label, Placebo (nL/P)	No Label, No Placebo (nL/nP) (identical to Meditation in Parts 1 & 2)

Figure X. 2x2 between-subjects design, all participants listen to the same guided meditation but differ in given information about the exercise.

Placebo Statement. In the Placebo condition (P), participants were told that the exercise was expected to improve their well-being. On the page prior to the exercise, they saw a highlighted and bolded statement that read: "You are about to participate in a relaxation exercise, which is expected to improve your well-being". In the No Placebo condition (nP), participants were told no additional information, as previously done. The nP statement simply read: "You are about to participate in a relaxation exercise".

Label. In the Label condition (L), participants were told that they were about to participate in a meditation. The word "meditation" was bolded, in a larger text size, and slightly brighter color. In the No Label condition (nL), participants were told that they were about to participate in a "relaxation exercise."

Platform, Participants and Recruitment

Participants were recruited via Prolific, an online platform where researchers may recruit participants from a large sample of Prolific users to participate in online studies and surveys. Prolific provides an option for "representative samples" of the US, in which the recruited participant sample matches the population proportions for sex, age, and ethnicity. This option was selected for the purposes of this study; however, slight deviations may have occurred due to the strict inclusion criteria. Participants had no prior knowledge (and by extension, no pre-

existing biases) about the fact that they would be participating in a *meditation* study, a key difference from nearly all meditation studies to date. This allowed us to measure expectations about study participation based on the limited but controlled information provided.

Analysis Plan

Primary analyses ask if there is a difference in meditation benefits based on whether participants were presented with (a) the label "meditation" versus the general descriptor of "relaxation exercise," or (b) a placebo statement saying they *should* improve versus no additional statement. All conditions participated in the same mindful meditation, differing only by the framing provided. Therefore, all conditions are expected to improve in well-being. However, (pre-registered) predictions include greater improvements in state stress and state anxiety in the Label (L) conditions compared to No Label (nL), and in the Placebo (P) conditions compared to the No Placebo (nP) conditions.

Secondary analyses will assess the role of Thoughts and Expectations in relation to meditation, as in Chapters 1 and 2, and ask how they relate to different knowledge levels of the task (Label) or belief in improvement (Placebo). As a manipulation check, measured expectations were predicted to be greatest in the Label, Placebo (L/P) condition, and lowest in the no Label, no Placebo (nL/nP) condition.

The following analyses will use a Bonferroni familywise error rate correction. Based on 21 planned tests (in Chapters 1, 2 and 3), the alpha value of $p = 0.05$ will be adjusted to a critical value of $p = 0.002$ for each individual test.

Results

Preliminary Analyses

Exclusions. Data collection continued until, after running the inclusion criteria code, there was a minimum of 400 participants (100 per condition). Data was collected from a total of *N*=546 participants. Consecutively, *n*=24 participants were removed for not finishing the study, *n*=4 were removed for failing more than one attention check, *n*=25 were removed for failing the subjective general engagement question, *n*=11 were removed for failing the survey subjective validity question, and finally *n*=73 were removed for failing the intervention subjective validity question. Therefore, the final sample of *N*=409 (104 L/P, 99 nL/P, 103 L/nP, 103 nL/nP) participants very likely gave their full effort and attention to participating. See *Inclusion Criteria*, in Chapter 1, for details on these items.

Demographics. This study had a sample of *N*=409 USA Prolific users, with a mean age of 43.7 years (with a SD of 15.7, and a range from 18 to 90). There were 193 (47%) who identified as female, 214 (52%) as male, and 2 (<1%) as nonbinary. There were 15 (4%) participants who identified as Asian, 26 (6%) as Hispanic or Latino, 307 (75%) as White, 47 (12%) as Black or African American, 2 (<1%) as Middle Eastern or North African, 10 (2%) as Mixed, 1 (<1%) as Native Hawaiian or Pacific Islander, and 1 (<1%) preferred not to answer.

Primary Analyses: Comparing Contexts of a Meditation Intervention

Does the framing of a meditation intervention influence how effectively it improves well-being? Specifically, do a placebo statement or the label “meditation” augment improvements in well-being? Normalized difference scores, indicating absolute percent change from before to after the 20-minute meditation, were calculated for the three measures of well-being: State Stress (SS), State Anxiety (SA), and Trait Anxiety (TA). Note that pre-scores for each of these

measures did not differ between conditions (SS: $F(3,405)=0.11$, $p = 0.95$; SA: $F(3,405)=0.22$, $p =0.89$; TA: $F(3,405)=0.06$, $p = 0.98$).

A one-way *ANOVA* on normalized difference scores for State Stress, State Anxiety, and Trait Anxiety by Condition revealed no effect of Condition on any measure (see Table 3.2). All conditions improved similarly in the three measures of well-being, regardless of whether there was a placebo statement and/or label (see Table 3.3).

Table 3.2

Fixed-Effects ANOVA(s) Results for State Stress, State Anxiety, and Trait Anxiety by Condition

Measure	*F*	*df*	*p*
State Stress	0.72	3, 405	0.54
State Anxiety	0.10	3, 405	0.96
Trait Anxiety	0.27	3, 405	0.85

Note. Condition levels are Label Placebo (L/P), Label no Placebo (L/nP), no Label Placebo (nL/P), and no Label no Placebo (nL/nP).

Table 3.3

Means (Normalized change pre- to post-Intervention) and Standard Errors by Condition

Measure	*L/P*	*L/nP*	*n/LP*	*nL/nP*
State Stress	-13.9 [1.5]	-14.2 [1.5]	-15.2 [1.8]	-11.9 [1.6]
State Anxiety	-9.2 [1.2]	-8.5 [1.2]	-9.4 [1.2]	-9.0 [1.0]
Trait Anxiety	-2.3 [0.6]	-2.7 [0.6]	-2.9 [0.6]	-3.0 [0.6]

Note. Standard Error (SE) of the means are shown in brackets. Condition levels are Label Placebo (L/P), Label no Placebo (L/nP), no Label Placebo (nL/P), and no Label no Placebo (nL/nP).

The pre-registered analyses followed a similar design as Chapters 1 and 2 and therefore implemented one-way ANOVAs comparing four levels of Condition. However, because these conditions were formed by crossing two variables—Label and Placebo—follow-up exploratory analyses asked whether there was an effect if difference scores were compared in a 2x2 ANOVA using Label and Placebo as the criterion. This approach gives more power to these variables

created by the experimental manipulations. However, as the pre-registered approach also conveyed, there were no significant results for either Label (p>0.3, p>0.8, p>0.7) or Placebo (p>0.9, p>0.7, p>0.6) on State Stress, State Anxiety, or Trait Anxiety, respectively. There were also no significant interactions.

Secondary Analyses: Mechanistic Role of Expectations and Thoughts

Does including a label or placebo statement alter measured expectations of improvement? If so, does this difference in expectations explain differences in actual improvement?

Expectation. Expectations were measured on a 100-point slider scale, with higher values indicating belief in improvement, and mid-range values indicating belief in no change to well-being, and lower values indicating a belief in worsening well-being after the exercise. Scores ranged from 24 to 100, which corresponded to the verbal statements "I think I will feel worse" and "I think I will feel much better," respectively. Of note, no participant chose lower than 20, which means no one believed "I will feel much worse."

Although the pre-registration predicted differences in measured expectations due to the differences in contextual information given, all conditions displayed similar expectations of improvement, regardless of whether there was a Label or Placebo statement (see Table 3.4).

Table 3.4

Mean Expectation Scores, Standard Errors, and Range by Condition

	L/P	*L/nP*	*n/LP*	*nL/nP*
Mean [SE]	76.8 [1.28]	76.1 [1.60]	75.4 [1.51]	75.6 [1.54]
Range	[49, 100]	[24, 100]	[45, 100]	[37, 100]

Note. Standard Error (SE) of the means are shown in brackets. Condition levels are Label Placebo (L/P), Label no Placebo (L/nP), no Label Placebo (nL/P), and no Label no Placebo (nL/nP). Range indicates [lower, upper] limits by condition, and possible range of Expectation score is [0,100].

The *ANCOVA's* on State Stress and State Anxiety by Condition and Expectation (see Tables 3.5 and 3.6) were non-significant. While only trending, the effect of Condition is

strengthened by the addition of Expectation in the models, and there may be an interaction. However, further study, likely with a more effective manipulation, is needed to draw any conclusions.

Table 3.5

Fixed-Effects ANCOVA results for Condition and Expectation using State Stress as the criterion

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{partial}\eta^2$	$^{partial}\eta^2$ 95% CI [LL, UL]
(Intercept)	0.52	1	0.52	19.88	.000		
Condition	0.13	3	0.04	1.70	.167	.01	[.00, .04]
Expectation	0.04	1	0.04	1.39	.238	.00	[.00, .02]
Condition x Expectation	0.17	3	0.06	2.21	.086	.02	[.00, .04]
Error	10.43	401	0.03				

Note. For partial eta-squared (η^2), a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared.

Table 3.6

Fixed-Effects ANCOVA results for Condition and Expectation using State Anxiety as the criterion

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{partial}\eta^2$	$^{partial}\eta^2$ 95% CI
(Intercept)	0.29	1	0.29	20.16	.000		
Condition	0.02	3	0.01	0.58	.626	.00	[.00, .02]
Expectation	0.04	1	0.04	2.55	.111	.01	[.00, .03]
Condition x Expectation	0.02	3	0.01	0.53	.659	.00	[.00, .02]
Error	5.68	401	0.01				

Note. For partial eta-squared (η^2), a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared.

Thoughts. Thought Valence was measured on a 7-point Likert scale, with higher values indicating positive thoughts, mid-range values indicating neutral thoughts, and lower values indicating negative thoughts. The *ANCOVA* on State Stress by Condition and Thoughts (see Tables 3.7) was non-significant. Again, while only trending, there appears to be a strengthened

effect of Condition and a potential interaction. However, there is still too much noise to draw any meaningful conclusions. The *ANCOVA* on State Anxiety revealed a marginally significant interaction between Condition and Thoughts (see Table 3.8). However, there is still too much noise and the confidence intervals for the effect sizes (partial eta-squared) fail to exclude zero. See Chapter 4 for further exploration of these variables.

Table 3.7

Fixed-Effects ANCOVA results for Condition and Thoughts using State Stress as the criterion

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\,\eta^2$	$_{\text{partial}}\,\eta^2$ 95% CI
(Intercept)	0.73	1	0.73	27.95	.000		
Condition	0.16	3	0.05	2.03	.110	.02	[.00, .04]
Thoughts	0.05	1	0.05	1.93	.166	.00	[.00, .03]
Condition x Thoughts	0.17	3	0.06	2.16	.093	.02	[.00, .04]
Error	10.44	401	0.03				

Note. For partial eta-squared (η^2), a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared.

Table 3.8

Fixed-Effects ANCOVA results for Condition and Thoughts using State Anxiety as the criterion

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	$_{\text{partial}}\,\eta^2$	$_{\text{partial}}\,\eta^2$ 95% CI
(Intercept)	0.46	1	0.46	33.28	.000		
Condition	0.13	3	0.04	3.23	.022	.02	[.00, .05]
Thoughts	0.07	1	0.07	5.34	.021	.01	[.00, .04]
Condition x Thoughts	0.14	3	0.05	3.27	.021	.02	[.00, .05]
Error	5.54	401	0.01				

Note. For partial eta-squared (η^2), a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared.

As an exploratory follow-up question, all the conditions were combined to assess general trends associated with meditation, as all conditions listened to the same mindful meditation

guided recording. Firstly, the relationship between meditation and thoughts seen in the secondary analyses of Chapter 1 (such that Thought Valence is unrelated to changes in State Stress) was replicated in this sample, although this analysis does not have the power of comparing to a control condition. As Figure 3.1 shows, regardless of experiencing negative thoughts during the guided meditation, participants showed equal improvements in State Stress as participants that experienced neutral or positive thoughts (r=0.05, p = 0.36). However, as the comparison with a control condition failed to replicate in Chapter 2, this effect requires further study to draw any meaningful conclusions.

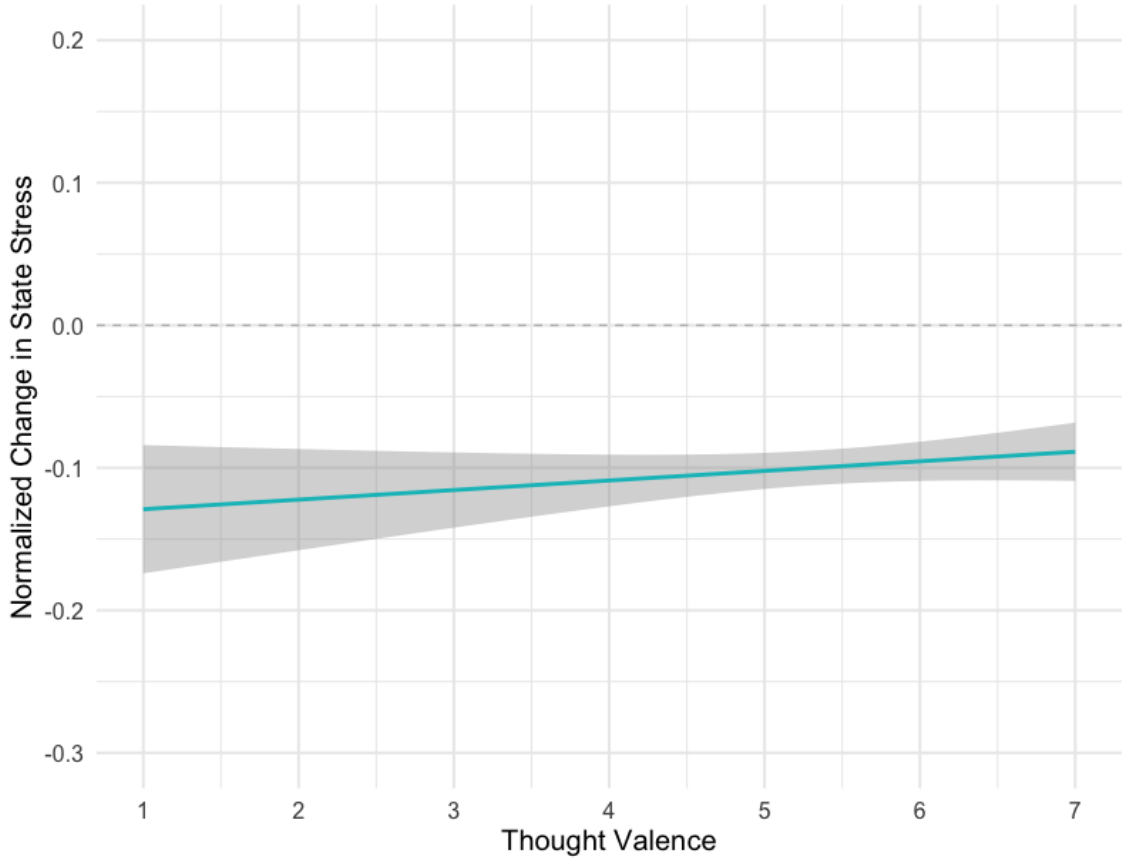


Figure 3.1 *Thought Valence in Meditation Does Not Predict Change in State Stress.*

Note. Data shown is collapsed across all conditions (all Meditation Intervention). Thought Valence ranges from 1 ("Very Negative") to 7 ("Very Positive"), with a score of 4 corresponding to "Neutral." Trend line shows 95% confidence interval on Pearson's product-moment correlation (r=0.05, p = 0.36).

Conclusion

Although results were non-significant, there are still meaningful insights to be gained from this study. Despite pilot data and the hypothesis that a Placebo statement and/or the Label "meditation" would augment expectations and improvements in well-being, there was no evidence for either case. There were no differences in improvements to well-being based on whether participants were presented with a Placebo statement or a Label. All conditions improved equally in well-being, reducing state stress by about 14%, on average, state anxiety by about 9%, and trait anxiety by about 2.7%. Measured expectation of improvement did not differ between conditions, nor did it have an effect on observed improvements in well-being. Thought valence showed trending results towards an interaction with Condition on improvements in well-being; however, there is too much unexplained variance to draw meaningful conclusions about the relationship.

Discussion

Interpretation of these results is cautious in the light of insignificant results. There were no differences between conditions, which could be for several reasons. One possibility is that the manipulation was insufficient to alter expectations. As this was an online, remote study that participants signed up for and completed on their own, perhaps the manipulated information (label, placebo statement) was not prominent enough. Indeed, it was surprising that the measured expectations were fairly equal across all conditions, which suggests that these manipulations did not work as intended. However, it is also possible that the label of "meditation" is no more powerful in inducing expectations than the label of a "relaxation exercise," nor is the inclusion of a placebo statement. If this is true, these results may be indicative of the power of the meditation itself, regardless of how it is labelled or presented.

These interpretations rely on the assumption that an expectation of improvement contributes to observable, or actual, improvements. While this assumption is corroborated by the placebo literature, it requires further study in the context of meditation. As these studies have shown, individual differences in expectations do not significantly predict observed improvements in well-being following a meditation. This may be due to inaccuracy in measuring expectations, or due to no relationship existing between expectations and meditation benefits. However, it is also possible that increased expectations, or differential expectations, only appear with repeated practice, and this study was too short to capture the relationship. While these results were not significant, they do provide insight that may guide future research in answering these important questions.

Chapters 1, 2, 3, and 4 are currently being prepared for submission for publication of the material. Bondi, Taylor E.; Dobkins, Karen. The dissertation author was the primary investigator and author of this material.

Chapter 4: Exploratory Explanations of Meditation Efficacy

Introduction

The previous chapters provide novel evidence of key components and mechanisms of improvement from a single session of mindful meditation. However, this is only a first step in establishing rigorous methods to quantify dose effects, understanding mechanisms and long-term outcomes of efficacious treatments, and creating a standard for replicable and reliable results. Among these goals, there is also a need for large, comprehensive studies that take other influences on well-being and treatment efficacy into account, such as psychological traits, demographics, and real-world settings. As there has been little research that address these extraneous variables explicitly, this chapter uses exploratory analyses to gain insight on potential variables of interest, in the hope of inspiring or informing future research.

Many variables may co-vary with meditation and well-being. Individual differences in experience, traits, or moods may contribute to how susceptible one is to potential benefits of a meditation. For example, many studies have shown that experienced meditators show greater improvements in well-being than novice meditators after a single session (Goleman & Schwarts, 1976). How might individual differences like these affect results? This section will not only isolate the unique effect of meditation amongst relevant covariates, but it will also give insight into how individuals, circumstances or traits may differentially benefit from meditation. For example, given that mindfulness and loneliness are negatively correlated (Bondi & Dobkins, 2020), someone that is extremely lonely might have a greater selective benefit from meditation than someone who isn't lonely. This chapter assesses the relationship between improvement due to meditation and a number of exploratory variables chosen for their proposed, hypothesized, or proven relationship with meditation efficacy.

Another related question is whether or not meditation is an equitable treatment. Are some people more likely to benefit from a meditation than others? Why or why not? Some negative effects of meditation have been found in clinical populations, such as individuals with schizophrenia or dissociative disorders (Dyga & Stupak, 2015); therefore, is it possible that there may be negative effects in understudied populations, such as minority groups? Because the majority of meditation research has been conducted with white, college-educated samples (Waldron et al., 2018), it is important to ask how these effects differ, or don't differ, in other populations. If therapists are recommending treatments to individuals from a wide variety of backgrounds, then it is important that all people are represented in the research that established the treatment (Miranda et al., 2003). By utilizing an online platform that offers representative samples based on age, sex, and race, research can start to shift towards including minorities and improving real-world treatment outcomes.

Finally, what is the real-world efficacy of meditation, for any individual? This chapter also assesses the efficacy of meditation as a treatment by performing and intent-to-treat analysis on the full sample of participants, which is nearly double in size compared to the sample used in the pre-registered analyses above, due to the strict inclusion criteria.

Methods

The following analyses were conducted as exploratory analyses, some of which have pre-registered predictions, using the same data collected for the confirmatory analyses presented in Chapters 1 and 3. Therefore, see Chapter 1 for details on measurements and protocol not described below. In addition to the Primary (outcome measures) and Secondary (mechanistic covariates) variables collected in relation to the Interventions, a handful of Tertiary variables were also collected for exploratory purposes, described below.

Measures

Tertiary Variables. Tertiary Analyses are mostly exploratory in nature, with the goal of further clarifying individual effects of condition on improved well-being by reducing noise and finding the best model, as well as determining moderating effects of variables that have previously shown to correlate with meditation effectiveness.

- Mindfulness: Five-Facet Mindfulness Questionnaire – 15 item (FFMQ-15; Baer et al., 2008; Gu et al., 2016). This is a 15-item scale that measures daily examples of mindfulness, or being aware of your thoughts, behaviors, emotions, and surroundings. Mindfulness is not expected to change and was therefore only measured once; however, studies have shown that individuals who score high in trait mindfulness may benefit more from meditation (Laurent et al., 2015; Bamber & Kraenzle Schneider, 2016).
- Previous meditation experience (PME): Because experience has been shown to produce greater benefits for meditators compared to novices (Goleman & Schwarts, 1976), it is important to measure how much experience each participant has had with meditation.
- Chronic Stress: Perceived Stress Scale (PSS; Cohen et al., 1983). This is a 10-item scale measuring the perception of stress and the degree to which the participant finds their life unpredictable, uncontrollable, or overloaded over the past month. As participants come in at different stress levels, chronic stress may explain participants susceptibility or openness to improvement (Goldin & Jazaieri, 2020).
- Loneliness: UCLA Loneliness Scale, Version 3 (Russell, D. 1996; Russell et al., 1978; Russell et al., 1980). This is a 20-item scale designed to measure one's subjective feelings of loneliness as well as feelings of social isolation. Because we have found consistent correlations between loneliness and mindfulness in previous research, we are

interested in potential differential effectiveness of meditation for participants experiencing loneliness.

- Enjoyment: Participants are asked, "How much did you *like* the exercise you just participated in?", which is answered on a 10-point scale with 3 markers (I disliked it, Neutral, I liked it).
- Insight: Because there is no mention of the words, "meditation" or "mindfulness" in most of the study, participants were asked about their insight into what the intervention is. With a free response, participants are asked: "In one word, what would you call the exercise you just participated in?" Expectations or biases might be greater with the knowledge, whether true or false, that one is meditating, which might also relate to amount of improvement from a meditation.

Samples

The following analyses answer several specific questions, repeating the analyses with two separate samples. The first sample is the "Undergraduate Sample," which is the sample collected for Chapter 1 using SONA, an online platform for students to earn extra credit by participating in research. For the majority of analyses, only participants that were randomized into the "Meditation" intervention will be used, as the questions relate to improvement due to meditation. The second sample analyzed is the "National Sample," which is the sample collected for Chapter 3 using Prolific, an online platform that offers "representative" samples of the United States by selectively recruiting users based on age, sex, and race. As all participants in this sample were assigned to the same Meditation intervention, differing only by the information presented, and no differences were found between conditions (see Chapter 3), all conditions were combined for the

purposes of these analyses. Because these samples were recruited separately and represent very different populations, they are presented as separate, repeated analyses.

Analysis Plan

First, analyses will explore how variables relating to personal traits, behaviors, experiences, and beliefs influence individual improvements in well-being following a meditation. Then, analyses will ask how demographic variables are related to improvements in well-being. Finally, an intent-to-treat analysis will explore the real-world efficacy of an online meditation in the full sample of undergraduate participants. For the purposes of these exploratory analyses, only State Stress was used as an outcome variable, as it showed the strongest results in the pre-registered analyses.

Chapter 4.1: Exploratory Explanations

4.1.1: Undergraduate Sample

The following analyses explore variables using the data from Chapter 1, in which undergraduate participants were randomized into either the Meditation or Control conditions. First, using only data from participants that were assigned into the Meditation condition, which variables predict improvement in well-being? In other words, which traits are associated with greater improvements in well-being following a 20-minute meditation? Table 4.1 describes the univariate relationship between the Tertiary Variable and improvement in State Stress following a 20-minute meditation.

Table 4.1

Univariate Relationships of Tertiary Variables with Changes in State Stress as a Result of Meditation in the Undergraduate Sample (N = 115)

Measure	Related to Improvement from Meditation?	Direction of relationship	Effect Size (Pearson's *r*)	*p*-value
PME	No	N/A	.03	0.7
Trait Mindfulness	Yes	lower mindfulness = greater change	.23	0.014
Chronic Stress	Yes	higher stress = greater change	-.45	< 0.000
Loneliness	Yes	more lonely = greater change	-.27	0.003
Enjoyment	Yes	more enjoyment = greater change	-.23	0.01
Insight	No	N/A	.09	0.3

Note. Previous meditation experience (PME) was log-transformed (typical for this variable as it tends to have an exponential distribution). 'Related to Improvement from Meditation?' indicates whether the variable is correlated with amount of change in State Stress following the Meditation Intervention.

Previous meditation experience did not predict improvement, despite some literature (Goleman & Schwarts, 1976) suggesting that experienced meditators are more likely to improve from a single session. Of note, this variable was log-transformed, which is typical for this variable as it tends to have an exponential distribution. Trait mindfulness was related to improvement; however, not in the expected direction. Lower trait mindfulness was associated with greater improvements. This is discussed later in relation to the full model, as this variable is highly correlated to chronic stress. Higher chronic stress predicted greater improvements in state stress. Higher loneliness also predicted greater improvements, such that lonelier individuals had bigger reductions in stress following the meditation. And as expected, greater enjoyment was associated with greater improvements. Finally, insight was coded as individuals correctly labelling the exercise as "mindfulness" and/or "meditation." In the Meditation condition, only *n*

= 17 (out of 115) participants had correct insight about the exercise, and this was not related to improvement. Since this variable might be unrelated to the actual exercise and more related to beliefs, this variable was also analyzed in the Control condition, in which n = 36 (out of 92) participants mislabeled the exercise as "mindfulness" and/or "meditation." Regardless, insight, whether true or false, was unrelated to improvements.

These univariate relationships may provide some insight into traits or circumstances that might improve meditation efficacy for various individuals. For example, meditation may "work best" when someone is experiencing high levels of loneliness or stress, but it might be ineffective if one does not enjoy the exercise. However, to get a better sense of the relative contributions of these tertiary variables in relation to each other, as well as to better understand the results of Chapter 1, a simultaneous model was analyzed using all collected variables, except PME (Previous Meditation Experience) and Insight, as these were unrelated to improvements. As Table 4.2 shows, the strongest predictors of improvement in well-being are Chronic Stress and Enjoyment. Chronic Stress is highly correlated with both Trait Mindfulness and Loneliness, which no longer significantly predict improvement in a simultaneous model. Of note, Chronic Stress predicts improvement above and beyond pre-scores of State Stress, suggesting that this effect is more than simple regression to the mean. As this model included participants in the Control condition, Intervention is still a significant predictor, and the interaction between Intervention and Thoughts (see Secondary Analyses in Chapters 1 and 2) is marginally significant. This suggests that meditation is explaining some improvements in well-being beyond these other factors. It also supports the results of Chapter 1 indicating that meditation may create a unique relationship with negative thoughts and mitigate their negative effects on well-being.

Table 4.2

Full Model Using State Stress as Criterion in the Undergraduate Sample (N = 207)

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 95% CI
(Intercept)	0.22	1	0.22	12.93	.000		
* INT	0.18	1	0.18	10.27	.002	.05	[.01, .12]
Thoughts	0.05	1	0.05	3.13	.079	.01	[.00, .07]
Expectation	0.04	1	0.04	2.55	.112	.01	[.00, .06]
Trait Mindfulness	0.00	1	0.00	0.18	.671	.00	[.00, .03]
*** Chronic Stress	0.43	1	0.43	25.20	.000	.11	[.04, .20]
Loneliness	0.06	1	0.06	3.65	.058	.02	[.00, .07]
*** Enjoyment	0.30	1	0.30	17.41	.000	.08	[.02, .16]
· INT x Thoughts	0.09	1	0.09	5.03	.026	.03	[.00, .08]
INT x Expectation	0.04	1	0.04	2.23	.137	.01	[.00, .06]
Thoughts x Expectation	0.03	1	0.03	1.80	.181	.01	[.00, .05]
Error	3.35	196	0.02				

Note. INT = "Intervention." For partial eta-squared (η^2), a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared. . p < .05, * *p* < .01, ** *p* < .001, *** *p* < .0001.

4.1.2: National Sample

The following analyses explore variables using the data from the national sample (collected via Prolific), in which all participants listened to the same Meditation Intervention. Although there were four conditions that differed in the information provided about the exercise (see Chapter 3), no differences were found between conditions. Therefore, for these exploratory analyses, data from all conditions was combined. Also of note, this sample was obtained using the nationwide platform of Prolific, in which a "representative" sample may be obtained in terms of age, sex, and race. Again, exploratory analyses ask which variables predict improvement in well-being? In other words, which traits are associated with greater improvements in well-being following a 20-minute meditation? For the purposes of these exploratory analyses, only State Stress was used as an outcome variable, as it showed the strongest results in the pre-registered

analyses. Table 4.3 describes the univariate relationship between the Tertiary Variable and improvement in State Stress following a 20-minute meditation.

Table 4.3

Univariate Relationships of Tertiary Variables with Changes in State Stress as a Result of Meditation in the National Sample (N = 409)

Measure	Related to Improvement from Meditation?	Direction of relationship	Effect Size (Pearson's *r*)	*p*-value
PME	No	N/A	.04	0.9
Trait Mindfulness	Yes	lower mindfulness = greater change	.25	< 0.000
Chronic Stress	Yes	higher stress = greater change	-.41	< 0.000
Loneliness	Yes	more lonely = greater change	-.32	< 0.000
Enjoyment	Yes	more enjoyment = greater change	-.18	0.0003
Insight	No	N/A	-.03	0.5

Note. PME = Previous Meditation Experience (log-transformed). 'Related to Improvement from Meditation?' indicates whether the variable is correlated with amount of change in State Stress following the Meditation Intervention.

The pattern of results replicates the pattern of results seen in the undergraduate sample above (Chapter 4.1.1). Again, after gaining some insight from these univariate relationships, a full model compares variables simultaneously in order to understand their relative contributions. All collected variables were included in the full model, except PME (Previous Meditation Experience) and Insight, as these were unrelated to improvements. As Table 4.4 shows, the strongest predictors of improvement in well-being are Chronic Stress and Enjoyment, replicating the results from the undergraduate sample. As all "Conditions" listened to the same Meditation, differing only by the information given to participants, there was no effect of Condition (as expected due to results described in Chapter 3).

Table 4.4

Full Model Using State Stress as Criterion in the National Sample (N = 409)

Predictor	Sum of Squares	*df*	Mean Square	*F*	*p*	partial η^2	partial η^2 95% CI
(Intercept)	0.27	1	0.27	14.12	.000		
Condition	0.13	3	0.04	2.29	.078	.02	[.00, .04]
Thoughts	0.06	1	0.06	2.98	.085	.01	[.00, .03]
Expectation	0.03	1	0.03	1.35	.247	.00	[.00, .02]
Trait Mindfulness	0.02	1	0.02	1.00	.317	.00	[.00, .02]
*** Chronic Stress	0.86	1	0.86	43.99	.000	.10	[.05, .16]
· Loneliness	0.09	1	0.09	4.87	.028	.01	[.00, .04]
*** Enjoyment	0.51	1	0.51	26.49	.000	.06	[.02, .11]
Condition x Thoughts	0.08	3	0.03	1.40	.244	.01	[.00, .03]
Condition x Expectation	0.10	3	0.03	1.74	.158	.01	[.00, .04]
Thoughts x Expectation	0.07	1	0.07	3.73	.054	.01	[.00, .04]
Error	7.62	392	0.02				

Note. For partial eta-squared (η^2), a small effect is .01, medium is .06, and large is .14. Values in square brackets indicate the lower and upper limits of the 95% confidence interval (CI) for partial eta-squared. · p < .05, * *p* < .01, ** *p* < .001, *** *p* < .0001.

Chapter 4.2: Meditation Equity

Chapter 4.2.1 Undergraduate Sample

Do some people benefit more or less from meditation? Is meditation an equitable treatment for different ages, sexes, and ethnicities? This section looks at the relationship between several demographic variables and improvement in well-being, measured by changes in state stress. As Table 4.5 shows, age is the only significant predictor of improvements in state stress following a meditation. However, as the age distribution was highly skewed, little insight can be drawn from these results.

Table 4.5

Univariate Relationships of Demographic Variables with Changes in State Stress as a Result of Meditation in the Undergraduate Sample (N = 115)

Measure	Related to Improvement from Meditation?	Direction of relationship	Effect Size (Pearson's *r*)	*p*-value
Age Mean: 20.9 years SD: 3.3 years	Yes	older participants = greater change	-.23	0.01
Gender Male: *n*=26 Female: *n*=89 Nonbinary: *n*=0	No	N/A	-.04	0.4
Ethno-Racial Background	No	N/A	.18	0.9
Country of Birth	No	N/A	.04	0.5

Note. 'Related to Improvement from Meditation?' indicates whether the variable is correlated with amount of change in State Stress following the Meditation Intervention.

Chapter 4.2.2 National Sample

Do some people benefit more or less from meditation? Is meditation an equitable treatment for different ages, sexes, and ethnicities? This section looks at the relationship between several demographic variables and improvement in well-being, measured by changes in state stress. Because this sample was collected from a national platform, additional demographic variables were included that are irrelevant to, or are too rare to garner representation of, an undergraduate population. These variables include education level, sexual orientation, and socio-economic status (SES, which was measured subjectively: "Relative to your peers, how do you feel about your financial situation?" Participants responded with a continuous slider scale with five statement breakers ranging from "I struggle with or worry about finances daily" to "I never struggle or worry about my financial situation"). As Table 4.6 shows, Age, Gender, Education and Subjective SES are all significant predictors of improvement in state stress after a 20-minute

meditation, whereas race and country of birth were not. Younger participants were more likely to show greater improvements, as were females and nonbinary individuals, participants with less education, and participants that reported more financial insecurity. This provides important preliminary results for developing targeted treatments and implementing low-cost or free meditation resources in areas where people are most likely to benefit from them.

Table 4.6

Univariate relationships of Demographic Variables with Changes in State Stress as a Result of Meditation in the National Sample (N = 409)

Measure	Related to Improvement from Meditation?	Direction of relationship	Effect Size (Pearson's *r*)	*p*-value
Age Mean: 43.7 years SD: 15.7 years	Yes	younger participants = greater change	.22	< 0.000
Gender Male: *n*=214 Female: *n*=193 Nonbinary: *n*=2	Yes	female & nonbinary participants = greater change	.18	0.0002
Sexual Orientation	No	N/A	.09	0.2
Ethno-Racial Background	No	N/A	.07	0.2
Country of Birth	No	N/A	-.04	0.5
Education	Yes	less education = greater change	.17	0.0006
Subjective SES	Yes	lower SES = greater change	.23	< 0.000

Note. SES = Subjectively reported socioeconomic status. 'Related to Improvement from Meditation?' indicates whether the variable is correlated with amount of change in State Stress following the Meditation Intervention.

Chapter 4.3: Meditation Efficacy

Chapter 4.3.1: Intent to Treat Analysis with Undergraduate Sample

Due to the implementation of strict, pre-registered inclusion criteria, the remaining sample used in the pre-registered analyses [of Chapter 1] was less than half the size of the original sample from which data was collected. This is largely due to the nature of the participant pool, in which undergraduate students may participate in online studies for course extra credit. Without the presence of a researcher to supervise or conduct the study, participants have a much lower threshold of attention given to the task. Additionally, the inclusion criteria had some subjective responses, which we have reasonable evidence to believe are valid (see Chapter 1 'Preliminary Analyses') and may have been too strict. And perhaps most importantly, although the primary focus of the pre-registered analyses was to determine mechanisms of improvement, establishing an overall or "real-world" treatment effect requires analyzing the full sample. Therefore, the following exploratory analyses replicate and expand upon the Primary Analyses in Chapter 1 using the full collected sample, with no exclusions.

The full sample included N=525 participants (MED: 259, CON: 266), in which only $n=12$ participants did not complete the study. Therefore, due to incomplete data for these participants, the sample used for analyses will depend on whether the measure was completed by some of these participants. See Table 4.7 for the number of participants in each Intervention that were excluded from the pre-registered sample.

Table 4.7

Distribution of Participants by Intervention and Exclusion Status

Intervention	Excluded from Original Sample	
	No	Yes
MED	115	144
CON	92	174

Note. "MED" = Meditation, "CON" = Control. "No" column represents original sample used in Chapter 1 pre-registered analyses.

Results

A one-way *ANOVA* on normalized difference scores for State Stress, State Anxiety, and Trait Anxiety in the full sample revealed a significant effect of Meditation on State Stress ($F(1,512) = 25.06$, $p < 0.000$), a significant effect on State Anxiety ($F(1,512) = 22.46$, $p < 0.000$), and as expected, no effect on Trait Anxiety ($p > 0.1$). These results are slightly stronger in significance and effect size than the pre-registered analysis in Chapter 1, which showed a marginal effect on State Stress and a trending effect on State Anxiety. See Table 4.8 for means of normalized difference scores, standard errors, and effect sizes.

Table 4.8

ITT: Means, Standard Errors, and Effect Sizes (Cohen's d) on Change in State Stress, State Anxiety, and Trait Anxiety for Meditation (MED) and Control (CON) Conditions in Full Sample (N=513)

Measure	*Mean Difference [and Standard Error]*		Cohen's *d*
	MED	*CON*	[95% Confidence Interval]
State Stress***	-0.180 [.010]	-0.114 [.009]	0.44 [0.27, 0.62]
State Anxiety***	-0.122 [.008]	-0.0744 [.007]	0.42 [0.24, 0.59]
Trait Anxiety	-0.0475 [.004]	-0.0352 [.006]	*NA*

Note. ITT = Intent-To-Treat. Means are normalized difference scores from pre- to post-Intervention. Effect size for Trait Anxiety was not calculated because there was not a significant effect. For Cohen's *d*, a small effect is 0.2, medium is 0.5, and large is 0.8. * $p < .01$, ** $p < .001$, *** $p < .0001$.

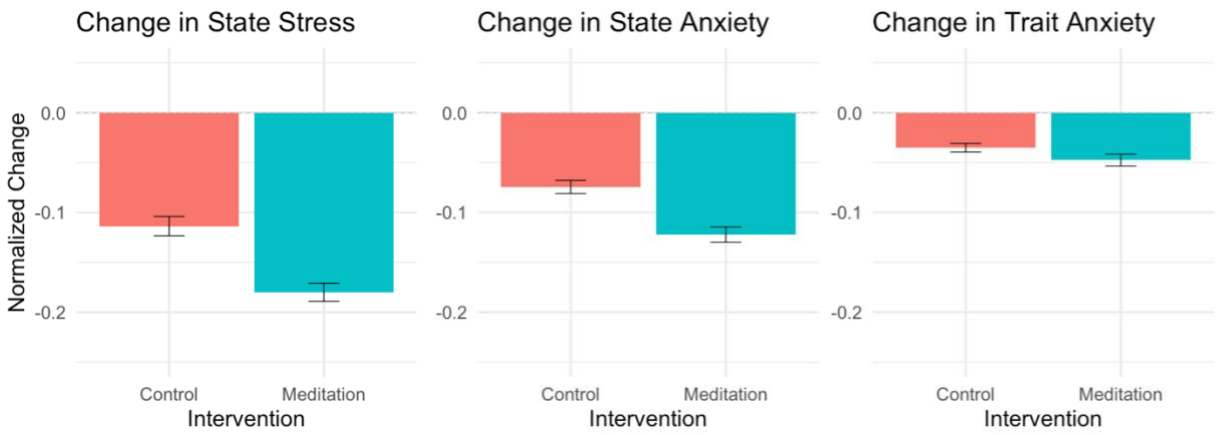


Figure 4.1 *Intent-To-Treat Analyses*

Note. Y-axes depict changes in normalized State Stress, State Anxiety, and Trait Anxiety from pre- to post-Intervention (post-pre/max), such that reductions in stress and anxiety indicate an improvement in well-being following a 20-minute Intervention.

Why do these results, using the full sample with no exclusions, show larger effect sizes than the original analyses? Participants were excluded based on effort and attention, measured both subjectively and objectively, given during the intervention and measurement portions of the study. Therefore, although excluded participants may have paid less attention, or given less effort to either the intervention or to responding to the survey questions, these participants nonetheless reported significant improvements in well-being. However, is this result due to a difference between exclusions in the meditation or control conditions? For example, perhaps more participants were excluded in the Control condition than in the Meditation condition, and by including them in the current analysis, the difference between conditions became larger. By testing for an interaction between Intervention and Exclusion Status, this possibility can be ruled out. Two-way ANOVAs on normalized difference scores in State Stress and State Anxiety using Intervention and Exclusion Status as criterion revealed a main effect of Intervention (SS: $F(1,510) = 25.4$, $p < 0.000$; SA: $F(1,521) = 22.9$, $p < 0.000$), such that Meditation improves well-being more than Control, and a main effect of Exclusion Status (SS: $F(1,510) = 8.7$, $p = 0.003$;

SA: $F(1,521) = 9.7$, $p = 0.002$), such that excluded participants (from the original analyses) showed less improvements in well-being, and no interaction (SS: $p > 0.9$; SA: $p > 0.3$),. As Figures 4.2 shows, the pattern of improvement for excluded participants is similar to, if slightly smaller in magnitude, to the included participants. This form of "replication" in the larger sample may explain the inflation of effect sizes as simply having more power. These results suggest that regardless of effort and attention level, Meditation seems to have a positive effect on well-being and is an effective treatment in a real-world setting (or more specifically, as an online, guided exercise for undergraduate students).

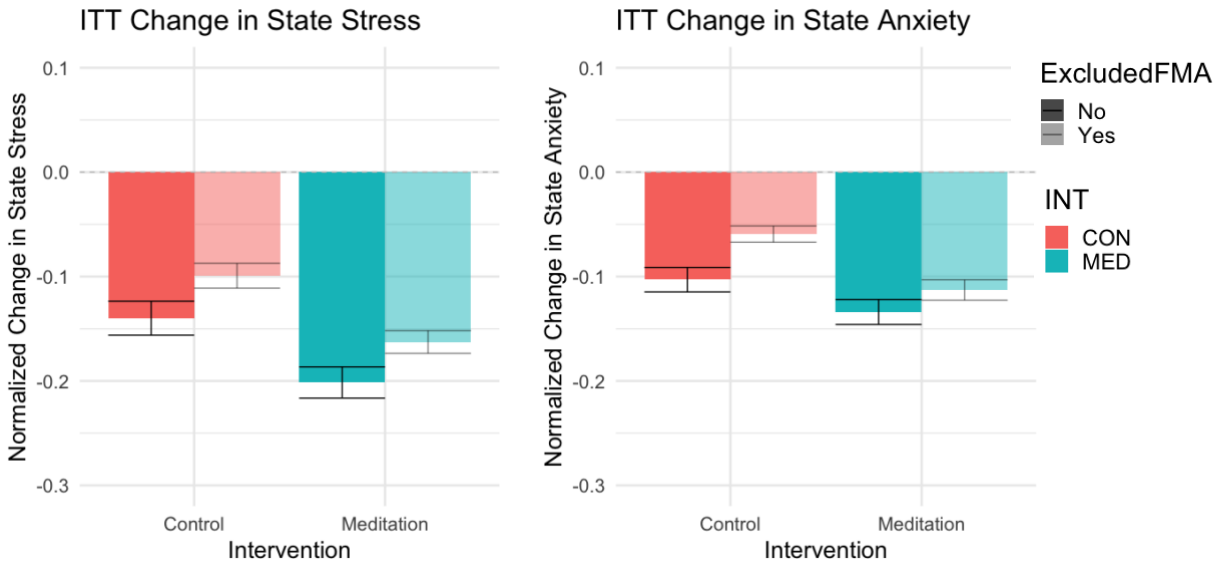


Figure 4.2 *ITT: Comparing Exclusion Status*

Note. Y-axes depict normalized change in State Stress and State Anxiety following a 20-minute Intervention (Meditation or Control). ITT = Intent-To-Treat. ExcludedFMA = Excluded From Main Analyses (in Chapter 1). INT = Intervention. CON = Control. MED = Meditation.

Discussion

As this was an exploratory chapter, strong conclusions cannot be made from these results. However, it is the hope that these results inform and inspire future research. Chronic stress of individuals should be a standard variable collected from any participant in a meditation study,

and likely included in analytical models as a covariate. Chronic stress is strongly correlated with likelihood to improve from a meditation, as well as related variables like trait mindfulness, loneliness, and SES. By including it in future research, the true effects and mechanisms of meditation may be isolated from related factors like chronic stress. Additionally, future research should aim to include minority groups in participant samples so as to better represent the full population and create equitable treatment standards.

The questions regarding effort, attention, and expectation in relation to meditation practice need further exploration. Results from the intent-to-treat analysis surprisingly show stronger results when including participants that were originally excluded for "inadequate" attention or effort given to the study. This raises new questions about what level of attention or effort is necessary, if any? Is meditation a passive or active practice, and would a guided audio recording be as effective as a more involved treatment? How does effort relate to expectation of improvement? Although there are many questions to explore further, these results offer initial insight into important related variables, efficacy of meditation as a treatment, and the importance of considering how research design decisions impact real-world outcomes.

Chapters 1, 2, 3, and 4 are currently being prepared for submission for publication of the material. Bondi, Taylor E.; Dobkins, Karen. The dissertation author was the primary investigator and author of this material.

Appendix

Intervention Scripts

Instructions

After filling out PRE questionnaires, participants will see one of the following instructions page. [note: instructions are the same for each intervention, differing only by the highlighted text.]

Meditation

You are about to participate in a 20-minute relaxation exercise. Please make sure you have functional audio (through your device, headphones, or speakers) and are seated in a comfortable position.

In this exercise, you will:

- *Remain seated in your chair*
- *Listen to a pre-recorded tape*
- *You will be asked to close your eyes and relax*
- *Then, you will be instructed to focus on your breath, and whenever a thought arises, to let the thought go and bring your attention back to your breath*

Breath

You are about to participate in a 20-minute relaxation exercise. Please make sure you have functional audio (through your device, headphones, or speakers) and are seated in a comfortable position.

In this exercise, you will:

- *Remain seated in your chair*
- *Listen to a pre-recorded tape*
- *You will be asked to close your eyes and relax*
- *Then, you will be instructed to take deep breaths, and whenever breathing becomes shallow, to return to slow, deep breaths*

Thought

You are about to participate in a 20-minute relaxation exercise. Please make sure you have functional audio (through your device, headphones, or speakers) and are seated in a comfortable position.

In this exercise, you will:

- *Remain seated in your chair*
- *Listen to a pre-recorded tape*
- *You will be asked to close your eyes and relax*
- *Then, you will be instructed to focus on your thoughts, and whenever the mind drifts, to follow the thought and figure out its meaning*

Detachment

You are about to participate in a 20-minute relaxation exercise. Please make sure you have functional audio (through your device, headphones, or speakers) and are seated in a comfortable position.

In this exercise, you will:

- *Remain seated in your chair*
- *Listen to a pre-recorded tape*
- *You will be asked to close your eyes and relax*
- *Then, you will be instructed to focus on your thoughts, and whenever the mind drifts, to let thoughts go without judgement*

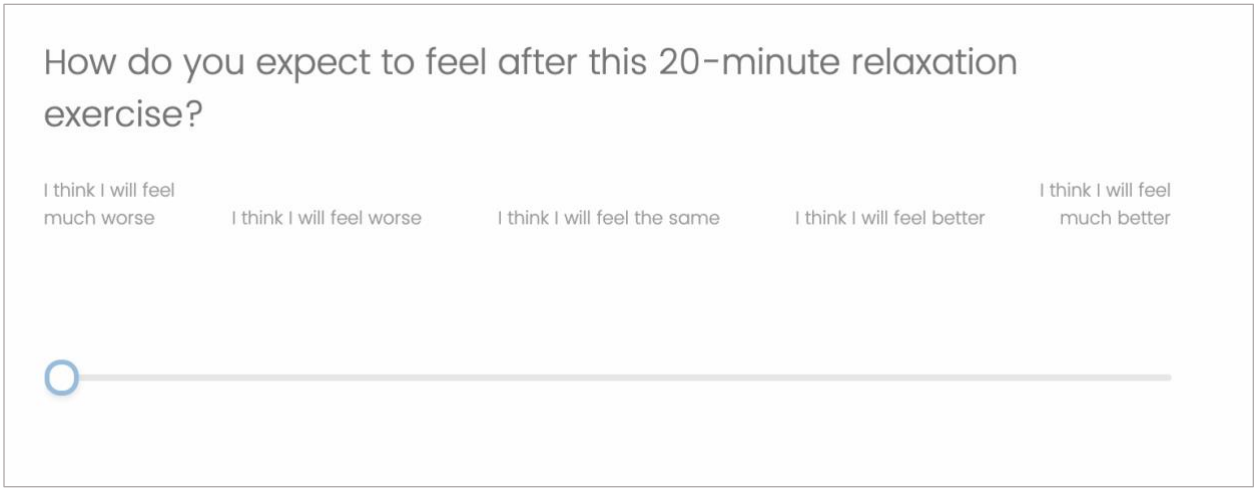
Control

You are about to participate in a 20-minute relaxation exercise. Please make sure you have functional audio (through your device, headphones, or speakers) and are seated in a comfortable position.

In this exercise, you will:

- *Remain seated in your chair*
- *Listen to a pre-recorded tape*
- *You will be asked to close your eyes and relax*
- *Then, you will be instructed to listen to information on various relaxation methods, and the science and benefits of these exercises*

After reading these brief instructions, subjects will answer one question on a slider scale. It will be a 100-point scale, 5 verbal markers (i.e. numbers will not be visible to participants, but used for analyses).



---page break---

When you are seated comfortably, have working audio, and are ready to begin the exercise, please proceed to the next page. The recording will start automatically, so make sure you are ready to begin before proceeding.

---page break---

Scripts

The following scripts are pre-recorded audio tapes.

Meditation

(5 second pause)
Welcome, I will be leading you through this exercise today. To begin, please close your eyes and relax, and let out a long, slow exhale.
(7s)
Relax all the muscles in your body, and take a few long, slow breaths through your nose.
(15s)
Bring your attention to the sensation of your breath. Slowly inhale and exhale through the nose, allowing each breath to flow more deeply.
(20s)
Find an easy, slow rhythm in your breath. Notice the air moving in and out of your nostrils, the air going up and down the back of your throat, expanding and contracting your chest and abdomen.
(30s)
[2:00] When you get distracted, either by your thoughts or feelings, simply notice the thought or feeling, and return your focus back to the breath.
(30s)
As thoughts come and go, try not to judge them as good or bad. Simply notice the thoughts move in and out of your mind, let them pass as you draw your awareness back to your breath.
(45s)
[4:00] Witness the flow of your breath, the pauses and spaciousness of the in breath and the out breath. Notice the filling of your lungs and belly as you breathe in, the emptying as you breathe out.
(1 min)
When your mind wanders, gently bring it back to the breath.
(45s)
Just focus on the sensations of your breath.
(1 min)
[7:45] Continue to notice passing thoughts with curiosity and compassion, let it go without judgement, and bring your attention back to the natural flow of your breath.
(1 min)
Let thoughts pass like clouds passing over a clear sky, and focus on the gentle flow of your breath.
(1 min)
[10:30] If your mind wanders, gently bring it back to the sensations of your breath.
(1 min)
Notice the steady expansion as you breathe in, the easy release as you breathe out.
(1 min)
[13:00] Continue to practice this on your own for the next few minutes. When your mind wanders, acknowledge the thought with compassion, and gently bring your focus back to the breath.
(2 min, 30s)
Just notice your breath. Allowing thoughts to pass without judgement. Continue to practice this in silence for about five minutes.
(5 min)
Now start to bring your awareness back to your surroundings, and gently open your eyes.

Breath

(5 second pause)
Welcome, I will be leading you through this exercise today. To begin, please close your eyes and relax, and let out a long, slow exhale.
(7 s)
Relax all the muscles in your body, and take a few long, slow breaths through your nose.
(15s)
Breathe in, and breathe out. Slowly inhale and exhale through the nose, allowing each breath to flow more deeply.
(20s)
Find an easy, slow rhythm in your breath. Let your breath become natural, and breathe now however feels right for you.
(30s)
Now take a few deep breaths through the nose. Long inhale, pause, and a slow exhale. Long inhale, pause at the top, and a slow exhale. And now let your breath fall back into a natural rhythm again.
(30s)
As you keep your breath slow and steady, I will prompt you every now and then to take a few long, deep, slow breaths. So take a big inhale now, and a long slow exhale. Inhale, long exhale. And now let your breath return to normal.
(45s)
Take another deep breath in, and exhale all of it out. Breathe in, and exhale through the nose. Now let your breath return to its normal pace.
(1 min)
Another deep breath in, and out.
(45s)
One deep breath in, and a long, slow exhale.
(1 min)
And inhale, filling your lungs with as much air as you can, and exhale it all out. Deep breath in, slowly exhale. Good, now continue to breath normally between these deep breaths.
(1 min)
Big breath in, slow breath out. Breathe in, breathe out.
(1 min)
Take three big breaths here through your nose. Long, slow inhale, pause, deep, slow exhale. In, and out. Once more in, and exhale. Now let your breath find a natural rhythm again.
(1 min)
Deep breath in, long breath out.
(1 min)
Continue to practice this on your own for the next few minutes. When your breath becomes short and shallow, take a few long, deep breaths through your nose, then let your breathing return to its natural pace.
(2 min, 30 s)
Just a reminder to take a few long, deep breaths every now and then, and breathe naturally in between. Continue to practice this in silence for about five minutes.
(5 min)
Now one last big breath in, and out, and gently open your eyes.

Mind

(5 second pause)
Welcome, I will be leading you through this exercise today. To begin, please close your eyes and relax, and let out a long, slow exhale.
(7 s)
Relax all the muscles in your body, and take a few long, slow breaths through your nose.
(15s)
Bring your attention to your thoughts. What thoughts are entering your mind? Are you talking to yourself inside your head, imagining talking to a person you know, or thinking of a scene, image, song, or feeling?
(20s)
Find where your thoughts take you. Are you planning for the future, or figuring out something from your past? Follow your thoughts to their conclusion, or to a new line of thought. Try and figure out what your thoughts mean.
(30s)
When you get distracted, allow your mind to wander where it naturally wants to go. Your thoughts are a reflection of who you are.
(30s)
As thoughts come and go, try to find one to follow and figure out its meaning. Whatever thought comes up, try to maintain focus on, and evaluate, it.
(45s)
Witness the flow of your thoughts, the conclusions you have drawn or the questions that have come up. Notice where your mind tends to drift, and what new ideas catch your attention.
(1 min)
When your mind wanders from this exercise, bring your attention back to your thoughts.
(45s)
Just focus on the contents of your mind.
(1 min)
Continue to follow new thoughts, to work out questions or problems that come up in your mind, or to concentrate on the narrative or images of your mental space.
(1 min)
Let thoughts take shape like clouds in the sky, choosing one to watch and focus on.
(1 min)
If your mind wanders, follow the new thought to see where it takes you.
(1 min)
Try to follow a trail of thought to its conclusion. What ideas or tangents do you find along the way?
(1 min)
Continue to practice this on your own for the next few minutes. When your mind wanders, follow the new trail of thought to its conclusion, or to a new thought. Maintain focus on the content of your mind, paying attention to your thoughts and what they mean.
(2 min, 30 s)
Just notice your thoughts. Focus on the content of your mind. Continue to practice this in silence for about five minutes.
(5 min)
Now start to bring your awareness back to your surroundings, and gently open your eyes.

Detachment

(5 second pause)
Welcome, I will be leading you through this exercise today. To begin, please close your eyes and relax, and let out a long, slow exhale.
(7 s)
Relax all the muscles in your body, and take a few long, slow breaths through your nose.
(15s)
Bring your attention to your thoughts. What thoughts are entering your mind? Are you talking to yourself inside your head, imagining talking to a person you know, or thinking of a scene, image, song, or feeling?
(20s)
Find where your thoughts take you. Are you planning for the future, or figuring out something from your past? Simply notice the thoughts move in and out of your mind.
(30s)
When you get distracted, either by your thoughts or feelings, simply notice the thought or feeling, and allow your mind to wander where it naturally wants to go.
(30s)
As thoughts come and go, try not to judge them as good or bad. Simply notice the thoughts move in and out of your mind.
(45s)
Witness the flow of your thoughts, let them pass as you draw your awareness back to your mind.
(1 min)
When your mind wanders from this exercise, bring your attention back to your thoughts.
(45s)
Just focus on the contents of your mind.
(1 min)
Continue to notice passing thoughts with curiosity and compassion, let it go without judgement.
(1 min)
Let thoughts pass like clouds passing over a clear sky
(1 min)
If your mind wanders, gently bring it back to the contents of your mind.
(1 min)
Simply notice the thoughts move in and out of your mind.
(1 min)
Continue to practice this on your own for the next few minutes. When your mind wanders, acknowledge the thought with compassion. Try not to judge them as good or bad. Simply notice the thoughts move in and out of your mind.
(2 min, 30 s)
Just notice your thoughts. Focus on the content of your mind. Allowing thoughts to pass without judgement. Continue to practice this in silence for about five minutes.
(5 min)
Now start to bring your awareness back to your surroundings, and gently open your eyes.

Control

(5 second pause)
Welcome, I will be leading you through this exercise today. To begin, please close your eyes and relax, and let out a long, slow exhale.
(7s)
Relax all the muscles in your body, and take a few long, slow breaths through your nose.
(15s)
While you are sitting quietly, keep your eyes closed and relax as you will listen to information about various relaxation methods, and the science and benefits of these exercises. You will be asked to internally reflect on what you are learning.
(5s)
Many people say that they find listening to music relaxing. To test this, scientists investigated whether listening to classical music would lower people's heart rate, which is an indicator of lowering stress. Each participant listened to Mozart for 20 minutes a day, for 3 days. The scientists compared resting state heart rate before vs. after the three-day intervention to see if it had changed. The results showed that for people over 30 years old, classical music reduced stress. But for people under 30 years old, there didn't seem to be a benefit from listening to classical music. Do you have any ideas why there would be an age effect? Reflect on what might explain this age difference.
(15s)
Do you think this result would change if a different style of music was used? What results would you predict for your favorite style of music?
(15s)
What else, besides heart rate, would you have liked to measure in this study? Do you think listening to classical music would affect anything else?
(20s)
In another study, scientists were interested in whether owning a pet reduces stress. They came up with an idea for a study to test this question: bring participants into the lab and randomly assign them into two groups. One group would receive a pet of their choice to take home with them, and the other group would receive a cute stuffed animal to take home. Then, they would see if the participants who took home a real live pet showed greater stress reduction over time, as compared to those who took home a stuffed animal. Unfortunately, the university at which they worked would not allow the scientists to do this study. Can you imagine some reasons why not?
(20s)
Because the scientists couldn't do the study that they originally planned, they came up with another idea. So, to test whether owning a pet reduces stress, the scientists decided to simply ask whether people who already own a pet report feeling less stressed than people who do not own a pet. To do this, they sent out a survey to 1,000 people in San Diego, and they indeed found that pet owners reported less stress in their lives than people who do not own a pet. The scientists concluded that owning a pet reduces stress. Do you see any problems with this conclusion?
(15s)
Do you think the results would change if they could have done their original study idea? Why or why not?
(15s)
Do you think the type of pet matters for this effect?
(20s)

There have also been many studies showing that exercising at least 3 days a week reduces stress and lowers the chance for cardiovascular diseases. Do you have any personal experience suggesting that this scientific finding is true? Either for yourself or others you know?
(15s)
What do you think of this amount of exercise? Do you think 3 days a week is good for everyone? What amount of exercise is best for you? And what happens when you exercise too little, or too much?
(15s)
How closely related do you think stress and cardiovascular health are? How have you noticed their link, in your life or in others you know?
(20s)
Other studies have shown the importance of sleep for stress reduction, as well as productivity, mood, and immune function. For example, one study showed that students who were sleep-deprived performed worse on a math test than students who had at least 7 hours of sleep. Do you think this result also provides evidence for how sleep deprivation increases stress? Why or why not?
(15s)
What else would you have liked to measure in this study? What other symptoms do you notice in yourself when you don't get enough sleep? How would you measure these symptoms?
(15s)
Do you think people vary in how much sleep they need? How much sleep do you usually need to feel rested?
(20s)
Another scientist was gardening one day and became curious about why he always felt so at peace while working in his garden. He wondered whether it was simply being outside and working with plants, or if it was because he was growing food that he will eat and enjoy later. So, he decided to test this question with a gardening study, where he brought participants into a lab garden to engage with different stages of the growing process. Half the participants planted seeds, and therefore took nothing home with them. The other half of the participants helped with harvest, and each took a small portion home. The scientist measured stress levels before and after gardening, and compared the changes in stress levels of the planters vs. harvesters. The gardening scientist found that both the planters and the harvesters had equal amounts of stress reduction. Therefore, what conclusions do you think this gardening scientist can draw?
(15s)
How generalizable do you think these findings are? Do you think results would change if this study compared different ages or cultures?
(15s)
Can you think of any other explanations for why gardening might be relaxing?
(20s)
Stretching can also be an effective relaxation method. A number of studies have shown that slow stretching or practices like yoga or or tai chi can lower someone's stress response. For example, one study showed that participants who did 30 minutes of stretching had lower cortisol levels than participants who did 30 minutes of reading. Based on this result, how do you think stretching works to relax you? Why do you think stretching is an effective relaxation technique?
(15s)
Do you find this result to be true from your own experience?
(15s)
What other control, besides reading, would you have implemented to compare with stretching?

(20s)
Some people find journaling to be a relaxing or therapeutic exercise. There are many forms and styles of journaling, so one scientist was curious about whether the topic of a journaling session was important for the therapeutic benefits. She brought participants into the lab and had them journal about an inspirational figure, where half of them journaled about a real person and half journaled about a fictional character that they admired. The scientist found that both groups showed equal benefits, and there was no difference between journaling about a fictional or factual person of inspiration. Which do you think is more relaxing, journaling about anything, or thinking about someone who inspires you?
(15s)
What other condition would you add to this study? What else would you ask participants to journal about?
(15s)
Do you think it was easier for participants to come up with a fictional inspirational figure (like Harry Potter) or real life inspirational figure (like Abraham Lincoln)? And for a real life inspirational figure, do you think it's easier to come up with someone from history or someone who is alive today?
(20s)
For about the next 2 minutes, think about whether there are other studies that should be done to test what practices and methods reduce stress. How would you test the effectiveness of a relaxation technique? How would you measure changes in stress? We discussed several biological measures, like heart rate and cortisol levels, as well as subjective measures of stress and inspiration, but what other ways of measuring stress can you think of? Reflect silently, with your eyes still closed, for the last two minutes of this exercise, and think of how you would define and measure changes in stress.
(2 min)
Now start to bring your awareness back to your surroundings, and gently open your eyes.

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