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Comparison of Vipassana Meditation with Other Mindfulness Traditions in the Response to Experimentally Induced Pain

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THESIS

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ABSTRACT

This study compared various mindfulness meditators with a meditation-naïve control group on multiple measures of pain tolerance and response. My primary hypothesis was that meditators would show greater pain tolerance than non-meditators and that they would also show greater parasympathetic nervous system activation in response to experimentally induced pain. The results were mixed, with meditators showing no greater increase in pain tolerance post-baseline. Differences in nervous system function between the two groups were also difficult to interpret.

Another component of the study was to explore the phenomenological reports and to compare and contrast those of the meditators and non-meditators using the qualitative method of Interpretive Phenomenological Analysis. This exploration revealed several differences in the responses to the pain tasks between the two groups and also revealed somatosensory phenomena that may be of interest to researchers investigating the response of meditators to painful stimuli and its application in pain management therapies.

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INTRODUCTION

Mindfulness meditation is a set of diverse and nuanced practices and is, therefore, difficult to succinctly define. It is often characterized as a process by which one's attention is brought to both exogenous (occurring "outside" the body) and endogenous (occurring "within" the body) phenomena, with the ultimate goal of observing these phenomena in an attitude of equanimity (Goldstein, 2010). Mindfulness-based meditation comprises numerous traditions, from Zen to Vipassana to therapeutic derivations like Mindfulness Based Stress Reduction (Kabat-Zinn, 2011). One common thread that connects these various traditions is the desire of practitioners to reduce their experience of suffering. In the context of meditative traditions suffering is often thought of as a fundamental feature of life, and the goal of practitioners is to be liberated from it, to no longer be experientially affected by it. But these traditions and their associated meditative practices also treat specific instantiations of this fundamental reality of suffering, from those considered primarily psychological, like day-to-day anxiety or the existentially wrought sense of individual mortality; to the suffering caused by physical pain—migraines to back-aches to the torment of terminal illness. As such there has been much recent research into how mindfulness meditation might be used to help manage chronic pain.

Pain Management and the Opioid Crisis

Chronic pain has reached epidemic proportions in the United States according to a 2010 study, which indicated that nearly 31% of American adults claimed to suffer from

it. The consequences of chronic pain are wide-ranging, from decreased quality of life to the severe economic effects of absenteeism and lower productivity (Edens & Gil, 1995). Chronic pain is also one the drivers of the opioid overdose epidemic in the US, which has resulted in increasing numbers of deaths per year over the past decade rising to over 47,600 deaths in 2017 (Scholl et al., 2018). Research into the link between chronic pain and the misuse of opioids has found that between 21% and 63% of people who misuse opioids have done so to alleviate chronic pain. (Han et al., 2017; Witkiewitz & Vowles, 2018). Research has also indicated that between 25% and 73% of people being treated for Alcohol Use Disorder have a history of moderate-to-severe chronic pain. Furthermore, there is a high prevalence of the co-use of opioids and alcohol by chronic pain sufferers, which may be implicated in many opioid related deaths (Witkiewitz & Vowles, 2018). It has therefore become incumbent upon the medical community to develop more efficient methods of pain management in order to reduce the amount of opioid medication prescribed and to give pain sufferers more effective psychological tools for dealing with chronic pain.

Research Into Mindfulness as a Pain Management Tool

The need to reduce opioid use in pain management therapies has been one of the primary reasons for the increase in research related to mindfulness-based meditation's effects on pain perception and response (nociception). The results have been mixed. A meta-analysis from 2015 (Bawa et al., 2015) showed that when patients suffering from a variety of non-malignant, chronic pain conditions (e.g., fibromyalgia, rheumatoid arthritis) received training in Mindfulness Based Stress Reduction (MBSR) or Mindfulness Based Cognitive Therapy (MBCT), they showed some limited increase in

perceived pain control. The perception of control has been defined as "the belief that the patient has the ability and resources to manage pain," and this perception of control can yield significant improvements in a patient's quality of life (Haythornthwaite et al., 1998, p. 33). However, this same analysis concluded that there were no significant changes in those patients' perceptions of pain intensity (how painful a particular sensation is), nor were there significant changes in the depression that can often accompany chronic pain. In contrast, a meta-analysis by Hilton et al. (2017) found significant improvements in depression and other quality of life measures in chronic pain sufferers, as did Ball et al. (2017) who found the positive impacts of mindfulness on a variety of measures significant enough to warrant the study of mindfulness-based interventions on the specific medical condition of Chronic Pelvic Pain. A randomized control trial by Cour and Peterson (2015) concluded, like Bawa et al. (2015), that the impact of MBSR training on many pain measures was mixed but did find a significant impact on their primary outcome of "vitality" which consisted of participants describing an increased feeling of being "more alive and energetic" despite suffering from chronic pain. Majeed et al. (2018) did a systematic review of MBSR-style interventions as well as "spiritualized mindfulness" on three specific chronic pain conditions—lower back pain, migraines and headaches, and musculoskeletal pain—and concluded that there was strong evidence in favor of mindfulness-based treatments for each condition. Finally, in contrast to the finding of Haythornthwaite et al. (1998) that mindfulness does not seem to decrease the perception of the intensity of painful stimuli (a central measure of pain tolerance) in chronic pain sufferers, other studies have indicated that mindfulness techniques are

effective in increasing pain tolerance in experimentally induced pain (Grant, 2013; Liu et al., 2012; Zeidan et al., 2011).

Experimental Versus Chronic Pain

There are several considerations at play that may explain the wide variance in these studies' outcomes. First, with regard to experimentally induced pain and pain tolerance, it should be noted that experimentally induced pain is time-limited, whereas chronic pain is not and is therefore associated with a slew of negative psychological phenomena. These can arise individually or in combination and often center around the hopelessness that accompanies the feeling (often experienced as *certainty*) that the painful stimuli will continue indefinitely, or on the debilitating sense of a general loss of well-being and vitality. For pain studies that use experimentally induced pain as a proxy for chronic pain to be valid, we must have confidence that there is a general applicability of the results of these studies to the experience of chronic pain. Edens and Gils' (1995) review of the research found that experimental pain was useful in the study and treatment of chronic pain in three ways. First, it helps researchers understand and manipulate several mechanisms involved in nociception, among them the complex interaction of phenomena such as hypervigilance (heightened sensitivity to pain over time) and adaptation (increased tolerance to pain over time), as well as how individual variance affects pain response and emotional affect. Second, experimental pain helps reliably determine and standardize pain intensity. Finally, and most saliently for studies of meditation's potential as an intervention for pain sufferers, experimental pain "provides an exciting and efficacious means of training both subjects without clinical pain and patients with clinical pain [both acute and chronic pain] in the use of pain coping skills"

(Edens & Gils, 1995, p. 212). The gist of the review is that, though there is some difficulty in drawing a direct connection between experimental and chronic pain, experimentally induced pain research is crucial for developing an understanding of the complex functions behind nociception and how they might be manipulated, and this understanding has been demonstrated to be applicable to sufferers of chronic pain.

Applying Mindfulness to Pain Management Therapies and Pain Research

A second consideration that needs to be addressed when considering the wide variance of mindfulness studies' outcomes regarding pain management is how researchers and therapists are applying the techniques of mindfulness in the exploration and management of chronic pain. Jacob (2016) cited research highlighting the potential effectiveness of mindfulness in pain management but stressed that "Learning for who and how [mindfulness] can work is at a very early stage" (Introductory Section). The paper emphasized the need, in light of the opioid addiction epidemic, to understand what populations of pain-sufferers might benefit from adding mindfulness techniques to their pain-management therapies and how to tailor those techniques to specific chronic pain conditions.

The quote from Jacob (2016) underscores two distinct challenges that researchers face in doing this. The first is understanding what conditions lend themselves to meditation-supplemented therapies. Recall the wide spectrum of successes and failures that programs like MBSR and its derivatives have had in treating chronic pain conditions. This may be attributable to the possibility that some conditions have neurophysiological origins that are more easily remedied by certain mindfulness practices than others or that cognitive re-framing is effective only when dealing with certain types or intensity-levels

of pain. Whatever the case, understanding how mindfulness training needs to be tailored to chronic pain therapies, in both general and condition-specific ways, is the second challenge facing pain researchers and therapists.

In point of fact, Mindfulness Based Stress Reduction and its derivative programs represent attempts to do just that. Developed in 1979 by Jon Kabat-Zinn, MBSR uses a combination of various mindfulness and yogic techniques, purposively stripped of their cultural and religious contexts, to help patients suffering from debilitating anxiety in addition to depression, pain, and other ailments (Kabat-Zinn, 2011). In the context of pain management, the method revolves around encouraging patients to "change the way they relate to pain by suspending judgment towards the thoughts accompanying the perception of pain" (Majeed et al., 2018, p. 80). The program is taught in an eight-week curriculum that includes one weekly group meeting, one full-day retreat, and a series of daily homework assignments and counseling sessions. Though the program is a fairly vigorous introduction to basic mindfulness practice, it does not require the same time commitment as a typical ten-day retreat nor is it as physically or psychologically strenuous. Because of this and because of its formulation in a clinical setting and its eschewing of metaphysical content, it has become the favorite method of many researchers who wish to teach particular groups a form of mindfulness for research purposes.

However, the main drawback to the MBSR-style approach is that it is nearly impossible to discern which specific mindfulness techniques, if any, are having an impact on pain management, or what the mechanisms are by which such impacts might be occurring:

> Most clinical studies are not well suited to establishing these mechanisms, since MBSR and related programs are complex and multifaceted, incorporating elements of various mindfulness-related techniques, such as breath awareness, body scans, and walking meditation, as well as physical exercise and stretching and training in cognitive reappraisal. (Perlman et al., 2014, p. 66)

Mindfulness Traditions Versus Mindfulness Techniques

These MBSR-style programs are consistent with, and arise out of, one of the primary approaches that researchers have used to try to understand and utilize mindfulness. I will call this the "techniques" approach in contrast to a "traditions" approach that is the foundation of my proposed research study. The "techniques" approach consists of attempting to isolate and extract specific mindfulness techniques from among the various mindfulness-based meditation traditions. Researchers then test these isolated techniques either individually or in combination. MBSR or one of its derivatives are the programs most often used in the latter combinatorial procedure, a procedure that is well-represented in the meta-analyses cited above. The first procedure revolves around testing different techniques in isolation. Because of variation in individual mindfulness practices, researchers have felt compelled to create categories in which to situate the techniques that are utilized by those practices. This allows them to limit the number of techniques that are researched by classifying them into general categories and researching and comparing those categories rather than researching and comparing each individual technique.

This can be illustrated by looking at an influential categorical framework developed by Lutz et al. (2008). The framework centers around two broad categories that

potentially encompass most mindfulness techniques. The first category is called Focused Attention (FA) and is centered, as the name suggests, around the focusing of attention on a specific object or activity. The second category is Open Monitoring (OM) which consists of becoming aware of any exogenous or endogenous phenomena that occur in the "present moment" and responding with an attitude of equanimity. Researchers have often treated these two categories as representing the totality of the practice of mindfulness, and mindfulness-based pain research has often revolved around comparing which of these broad categories of techniques is more effective at moderating the experience of pain and how such moderation differs at both the experiential and neurophysiological levels. A study that exemplifies this approach is Perlman et al. (2008) in which researchers used 9 Long-term Meditators (LTM) who practiced a form of Tibetan Buddhism and had these participants engage in techniques from their tradition that fit most closely with the FA and OM classifications. They then compared how well these techniques were able to moderate ratings of pain intensity and levels of "unpleasantness" (how much the pain distressed them) in the face of thermal-induced painful stimuli. The important point to note here is that the researchers were testing which specific technique might be most efficient at moderating pain, but they were compelling their participants to engage in those techniques in isolation. In the Tibetan traditions that the participants practiced, the two techniques that were used can indeed be separated into distinct techniques, but the tradition utilizes both, in continuous combination, in its overall practice. By disengaging one from the other in the way that the researchers compelled the participants to do, part of the traditional practice, as well as its benefits, is potentially lost.

Grant (2013) conducted a meta-analysis of meditation studies related to pain (which included the Perlman et al. study). Grant used the same classifications (FA and OM) to categorize and analyze these studies, and his conclusions focused on which of these techniques is more effective. Grant added a third technique in his analysis, that of Compassion meditation, and this highlights the limits of classifying mindfulness primarily according to the two categories of FA and OM.

Several issues need to be addressed here. The first is that the techniques approach to meditation research is undoubtedly valuable and should continue. However, what is lost in this approach is the emergent experiential reality at the heart of individual meditative traditions. This has been done largely for convenience's sake as the number and variety of traditions and their associated meditative practices makes it hard to tease out what might be happening with individual meditators as well as which aspects of meditative experience might be useful outside of the context of the traditional practice. But it is all too easy to forget or ignore that these meditative traditions were not developed primarily for pain management or to deal with any of the many ailments that researchers wish to apply them to. Braun (2013) describes the situation like this:

> Nonetheless, the understanding of mindfulness as just bare awareness [in the context of research, both FA and OM would qualify here] has led in recent years to a wealth of psychological studies and secular movements extoling its benefits. Mindfulness has become a separate, healing practice in its own right, rather than one mental factor among others in successful insight practice. (p. 166)

Though the "healing" aspects of mindfulness meditation are pursued and encouraged by practitioners and teachers across both the West and Asia, the primary purpose of the

meditative traditions that utilize mindfulness techniques is achieving a state of liberation, a state of being "awakened" to the reality behind appearances. Any positive health effects are secondary and are often seen as unworthy goals of meditative practice[1]. Analayo, the pre-eminent modern scholar and expositor of the *Satipatthana Sutta* (the ancient manual at the heart of Theravadin Buddhist meditation practice) has made a related point: "mindfulness should be established merely for the sake of developing bare knowledge and for achieving continuity of awareness" (Analayo, 2003, p. 18). In other words, mindfulness is part of an overall method for the attainment of certain states of mind that are of real value, that are the real goal of practice; mindfulness has limited value in and of itself. That mindfulness has been shown to help ameliorate pain, or stress, or other ailments of the body and mind is something that should continue to be researched. But we should take to heart the actual purpose to which it was put in the traditions from which it has been extracted. As researchers we should not feel compelled to hold to the metaphysical views that often accompany the meditative traditions we are studying, but it is incumbent upon us to understand the context which these traditions represent and in which they operate. The practical reason for this can be illustrated by looking more closely at Vipassana in the tradition of S.N. Goenka, the meditative tradition at the center of my study.

Vipassana in the Tradition of S.N. Goenka

[1] An anecdote told by the Vipassana master, S. N. Goenka, concerns being denied entry to his first ten-day Vipassana meditation course by U Ba Khin, the man who would become his teacher. Goenka's faux pas was admitting that his primary reason for wanting to attend the course was to find a cure for his debilitating migraine headaches. Goenka was eventually allowed entry when he agreed to practice with the goal of attaining Insight as his primary motivation.

This style of Vipassana is strongly focused on physical sensations and utilizes a technique of systematically "scanning" the body, head to toes, in an effort to become aware of any sensations occurring in the parts of the body that the meditator's attention is being passed through. Physical sensations are divided between "gross" and "subtle." Gross sensations are those that we typically think of as pertaining to our physical experience—sensations running the spectrum from broad categories such as pain (which can be further subdivided and categorized into sharp, dull, hot, etc.) to specific individual sensations like itchiness, or the feel of cloth against the body or the breath passing over the upper lip.[2] The term "subtle" to denote the second set of sensations implies that they are simply more refined or weaker versions of gross sensations. But subtle sensations are qualitatively different from gross sensations, and the term "subtle" is likely a metaphysical residue of the Indian philosophical tradition that holds that there is a spiritual/energetic component of human beings, a subtle body, that exists within the physical body. Meditators in this tradition typically begin to experience these subtle sensations during the final days of their initial ten-day course of instruction.[3] These sensations are difficult to describe and are often referred to by practitioners as "vibrations" or "energy". Setting aside a precise phenomenological analysis, the most salient aspects of the experience of these sensations are that they are very pleasant and that they arise solely as a consequence of focused and prolonged attention systematically directed at the body. At the initial stages of this practice, both gross and subtle sensations

[2] When Goenka introduces the practice during a ten-day course, he gives a fairly comprehensive and unintentionally comical list of the possible gross sensations a person might experience: "Maybe an itchy sensation or a tickling sensation. Maybe a sensation of heat or maybe one of dryness. Maybe a sensation of moist [sic]," and so on….

[3] All instruction in this tradition occurs during ten-day courses offered by the organization founded by S. N. Goenka. There are no books or video tutorials available.

are used as tools to develop one's equanimity. Subtle sensations allow a meditator to observe pleasant physical phenomena in a state of non-reactivity. This theoretically results in a reduction of what Buddhists classify as "attachment" or "clinging," and this reduction is thought to be generalizable to the bulk of one's lived experience. To similarly diminish the meditator's opposite tendency toward "aversion", meditators are instructed during the three daily hour-long group meditation sessions that occur during a ten-day course to remain perfectly still. This is experienced as particularly unpleasant to novice practitioners. Movement restriction is known to be painful and has been used extensively as a tool of what the CIA euphemistically referred to as advanced interrogation techniques (Jovic & Opacic, 2004). Of course, there is a substantial difference between experiencing the discomfort of restricted movement in the relative comfort and safety of a temperature-regulated meditation center and that experienced by the unfortunates being punished or pressed for information by interrogators who are likely using additional techniques and for whom one's best long-term interests are of limited consequence. But this utilization of restricted movement in the instruction of Vipassana does create a legitimate experience of pain, and the meditator is trained to respond to that pain with "perfect" equanimity. This is one of the aspects of Goenka-style Vipassana training that sets it apart from most other mindfulness-based meditation traditions and makes it of special interest to researchers whose goal is to utilize mindfulness in the development of clinical interventions for sufferers of chronic pain.

In the context of a traditions approach to meditation research, what is of note in the above description of Vipassana is that the FA and OM components of the practice are essentially synthesized in order to produce a set of experiences, both pleasant and painful,

that are then used to develop the meditator's equanimity. As one develops in this practice and the subtle sensations that arise from this synthesis of attention (FA) and equanimity (OM) grow more powerful, the meditator attempts to arrive at a state of dissolution (a state where all that one experiences are subtle sensations) and to see that the nature of that experience is continual flux and essential impermanence. The mindfulness factors are primarily tools to develop this direct, experiential understanding, and this understanding represents an emergent experiential property of the tradition, one that is not reducible to either FA or OM. This understanding is the goal of the practice, and it cannot rise without the continual synthesized utilization of the mindfulness techniques operating in a specific conceptual context. If a researcher were to compare the FA component of this practice to the OM component, or to compare Vipassana practitioners' facility at one or both of these techniques with practitioners of a different mindfulness-based meditation tradition, the results might be of theoretical as well as therapeutic value. But what would be lost is the tradition being practiced in its emergent fullness. And it might very well be that the greatest benefits engendered by the practice, for both the amelioration of pain as well as the more ethereal goals of "liberation", only come as one progresses through its various stages.

Challenges of a Traditions Approach

Of course, the traditions approach to meditation research presents numerous challenges, chief among them how to define what constitutes a legitimate meditative tradition. Does MBSR qualify by dint of its systematic approach to the utilization of mindfulness techniques? Or does its primary goal of stress-reduction mark it as Western-style, psychological self-help rather than one of the traditions that attempt to push past

such a restricted scope to the experience of full release from all forms of suffering?[4] From a research perspective a strong argument could be made that we should compare MBSR on any number of measures (pain, stress, depression, etc.) against the more "established" traditions like Zen or Vipassana. The challenge here is that MBSR, because of its narrow motivational focus, is much less likely to develop meditators who have the same level of meditative experience as the long-term practitioners of other traditions. The comparisons would be limited to novice practitioners and though such comparisons might yield useful results, they would not allow for the exploration of more advanced meditative states or the impacts on specific mental and physical conditions that might result.

Another challenge faced by the traditions approach is how best to incorporate the meditation practices of these traditions into pain-management therapies. It is impractical and potentially offensive to encourage a sufferer of chronic pain to accept, whole cloth, the full practice and context of any one of these traditions. How does that difficulty limit the practical application of a traditions approach?

These concerns will find their solution over time and are beyond the conceptual scope of the present study, a study which represents but one incremental step toward a more complete understanding of the meditative traditions and how we might utilize them in the context of pain-management. It is, in part, an attempt to reinforce the work of other

[4] It is important to note that Jon Kabat-Zinn teaches a much fuller form of mindfulness meditation outside of the specific context of MBSR. Out of an obvious desire to alleviate his patients' suffering, Dr. Kabat-Zinn developed what amounts to a mindfulness primer, a way for people to create enough mental space, enough distance from their stress and discomfort, to begin the process of observing what is happening with some degree of equanimity. This has had a tremendous positive impact and I do not wish to diminish his efforts or paint him as someone who does not understand the traditions out of which he has created his system.

researchers who have begun to recognize the great variance in meditation practices and how those differences need to be factored into any study of mindfulness' effects (Grant & Zeidan, 2019; Lutz et al., 2007; Von Baeyer et al., 2005). We need both the techniques and traditions approaches, functioning in a variety of contexts, if we are to come to a sophisticated understanding of the nature and applicability of these practices.

CURRENT STUDY

Objectives

My primary objective in the current study was to compare the pain tolerances of a specific group of Vipassana meditators (those trained in the tradition of S.N. Goenka) with a meditation-naïve control group, and with a group of moderately to highly experienced meditators trained in other mindfulness-based meditation traditions or techniques. I hypothesized that the meditation groups would have significantly higher thresholds of pain tolerance, and that the Goenka-style Vipassana group would score significantly higher than either of the other groups.

I also performed semi-structured interviews to examine the phenomenological experience of each participant, looking specifically for common and divergent themes with a primary focus on how the experience of pain, in both its perceptual and sensational aspects, changed from the first cold-pressor task to the second.

A final objective was to discover whether either of the meditation groups showed significant attenuation of autonomic pain responses as measured by heart rate variability and galvanic skin response.

Though it was important to me to maintain my study's original intention throughout the process of data collection and in my thesis' presentation of its rationale

and results, it must be stated clearly that recruitment difficulties made it impossible to adequately explore the differences between Vipassana meditators and meditators of other traditions or who utilize other techniques. I was forced to focus much of my analysis on a comparison of a composite group of meditators made up of Vipassana and non-Vipassana practitioners, as was approved during the thesis proposal process. Though the study was underpowered, I have attempted, whenever possible, to highlight the differences between the Vipassana meditators (who most fully represent a single tradition practiced in its fullness) and the non-Vipassana meditators, in both the quantitative and qualitative dimensions of the study.

Neurophysiological Components of Current Study

Jacob (2016) focused on the need to understand the underlying neural processes associated with mindfulness practice and how they might affect nociception. To help further this understanding, I attempted to isolate some of the specific effects mindfulness may have on the autonomic nervous system processes influencing pain response (nociception). One theory as to how mindfulness might attenuate the experience of painful stimuli is by increasing attention on the resulting sensations, which results in increased recruitment of the neural representations of the stimuli in sensory areas. At the same time appraisal centers in the prefrontal cortex are less engaged than in normal nociception, which results in a reduction of the perceived intensity of the painful stimuli. Essentially, meditation might cause a disengagement of the "top-down" aspects of nociception (the appraisal process that takes place in prefrontal areas) while simultaneously increasing the "bottom-up" part of nociception (perception of and attention to the actual painful stimuli) (Gard et al., 2012; Zeidan et al., 2011).

Arousal of the sympathetic nervous system is associated with the experience of noxious stimuli. The greater the level of arousal, the more intense the stimulus is perceived to be. One long-standing measure of sympathetic nervous system arousal is heart-rate variability (HRV). HRV decrease is associated with greater activation of the sympathetic nervous system while increases in HRV are associated with greater activation of the parasympathetic nervous system or with a healthy balance between the two. The initial response to painful stimuli usually results in a decrease of HRV as heart rate increases (leaving less space for variability) but this decrease is potentially moderated by distraction from, or attention to, painful stimuli (Petrovic et al., 2004). It is possible that mindfulness meditation causes a shift from sympathetic nervous system activation to parasympathetic nervous system activation, and thus, helps attenuate the experience of painful stimuli. This shift can be measured by the ratio of high frequency to low frequency readings in heart-rate-variability data called the sympathovagal balance. When analyzing HRV, the intervals between successive heartbeats, or RR intervals, are measured. Lower frequency RR intervals are mediated by fluctuations of both parasympathetic and sympathetic nerve activity, while higher frequency RR intervals are mediated by fluctuations of vagal nerve activity alone, which predominantly indicates parasympathetic nervous system activation. The ratio of these frequencies (lower/higher) provides a rough sketch of which division of the nervous system is exerting greater influence and, thus, how distressed or calm a person might be (Jeranth et al., 2014; Eckberg, 1997). To look more closely at the level of parasympathetic nervous system activation in isolation, I also used an index of pNN50 which is correlated to high-frequency HRV. pNN50 looks at the number of successive R-R (NN) intervals that are

greater than 50 ms. and is a reliable measure for changes in cardiac vagal tone that indicate parasympathetic activation. (Kleiger et al., 2005)

To further examine the role of general nervous system fluctuations, I also used a measure of Galvanic Skin Response (GSR). GSR is a long-standing tool for measuring the activation of the sympathetic nervous system and is especially useful for measuring the initial, brainstem-centered, automatic response to noxious stimuli. This response is thought to occur independently of any "conscious experience of pain" (Petrovic et al., 2004, p. 1002) and can potentially allow us to see any changes in the "bottom-up" aspect of nociception and how meditative practice influences it.

Phenomenological Component of Current Study

Another dimension of the study takes it from the quantitative realm of empirical research to the qualitative. A scattering of studies on meditation over the years have incorporated a phenomenological analysis of the lived experience of meditators. This has often focused on the qualitative difference in meditative experience between novice and expert meditators as well as differences in the intensity of those experiences or how well the meditators were able to apply the meditative practices in their lives (Kaselionyte & Gumley, 2017; Shaner & Kelly, 2017; Kjellgren, 2008). However, little attention has been paid to the phenomenology of meditators' response to pain. A recent study by Poletti et al. (2021) has done just that. In it, 30 long-term meditators in the Kagyu and Nyingma schools of Tibetan Buddhism were compared with 32 novice practitioners who were taught a simple version of a meditative practice patterned on the FA and OM practices contained within those schools. Each practitioner experienced thermal-induced painful stimuli and rated their levels of pain intensity and distress. They were then

interviewed by the researchers, and the interviews were analyzed using the standard procedures of Interpretive Phenomenological Analysis (IPA). Several phenomenological "clusters" that were common to both the expert and novice groups described specific responses to the painful stimuli that might be generally considered mindfulness-inspired cognitive reframing. This reframing intensified in the expert meditators who described the pain as an opportunity to observe and better understand cognitive processes.

The IPA element of my study was modeled, in part, on what Poletti et al. did, though the tradition I was interested in highlighting was different, and it was motivated by a more general exploratory spirit, one that sought to understand how the experiences and responses to pain differed as a function of meditative practice and especially what distinctions might mark the experience of Vipassana practitioners. I was also much more focused on the physical sensations of pain as I predicted that this aspect of the experience would most likely highlight the unique contributions Vipassana practice might be able to make in the utilization of meditation in pain management.

In basic terms, IPA is concerned with the analysis of a kind of dual perspective that emerges through the interaction of subject and researcher (Smith et al., 2009; Smith & Osborne, 2015). The first part of this dual perspective is focused on self-reported details of a subject's lived experience. The second part arises from a researcher's analysis of those reports in an effort to glean meaning from them and to explicate the primary or foundational components of the subject's experience. In many cases, a researcher's analysis can reveal aspects of the experience that the subject may not have been fully aware of. In studies that use group comparisons these foundational components of experience can be compared across subjects to find both experiential invariants and

points of divergence. The procedures of IPA begin with semi-structured interviews that attempt to extract a detailed report of particular aspects of a subject's experience as well as general background information that may be relevant to how a subject interprets those experiences.

The semi-structured interviews (SSIs) for my study were conducted after completion of the first stage of data collection—both cold-pressor tasks and their respective assessments (discussed below). They began with a brief discussion of the subject's experience in meditation and supplemented the meditation questionnaire that was completed before data collection. The interviews were then broken into three basic parts, each of which looked at one phase of the study: The first and second cold-pressor tasks and the ten-minute period between them. For each part I began by asking the subject to simply describe his or her experience after which I asked follow-up questions in an effort to draw out as full a description of that experience as possible. I also specifically asked about the physical sensations each subject experienced and whether those sensations were confined to the hand or were felt in other areas of the body. When I asked about physical sensations I did so in a basic way that initially allowed the subject to answer however they wished. I then asked follow-up questions in order to flesh out the details of the experience.

This focus on physical sensations in the interviews was an effort to address a specific secondary hypothesis. Vipassana, in the Goenka tradition, is highly focused on the experience of "subtle" sensations, and the type and intensity of that experience marks, to some degree, progression within the tradition. At intermediate to advanced stages of the practice, meditators are said to experience a dissolving of "gross" sensations like pain

and the replacement of those sensations with subtle ones. This is a potentially testable claim and, based on it, I hypothesized that there would be a strong association between the experience of subtle sensations by Vipassana meditators and an increase in pain-tolerance post-baseline as well as a decrease in pain rating, pain distress, and sympathetic nervous system activation. I also wanted to see whether meditators of other traditions experienced anything like subtle sensations and how integral they were to their response to painful stimuli. It is possible that these experiences are common to meditative practice and that this commonality is obscured by different terminology or by a variance among the meditation traditions in the importance placed on sensations. Whatever the case, a qualitative analysis of the meditators' experience was required to gain access to these experiential components.

METHOD

Participants

This study involved three groups of participants: one meditation-naïve control group, one meditator group specifically trained in the practice of Vipassana (the Vipassana meditation group), and one general meditator group trained in any other mindfulness-based meditation tradition. The control group consisted predominantly of college students recruited via the SONA site. Eight females and four males participated in the final sample, with a mean age of 24.2 years (SD = 7.05 years). The general meditation group consisted of meditators with at least one-hundred hours of meditation experience (to match the minimum experience of the Vipassana group) in any of the mindfulness-based meditation traditions or techniques that have been used by researchers in past studies. They were recruited through SONA and through community advertising. Four

females and four males participated in the final sample, with a mean age of 41.4 years (SD = 9.65 years) and a mean meditation experience of 1850 hours (SD = 2011 hours). The Vipassana meditation group consisted of meditators trained in Goenka-style Vipassana who had completed at least one ten-day course (the equivalent of approximately one-hundred hours of practice) with Goenka or one of his assistant teachers. One female and two males participated in the final sample, with a mean age of 28.0 years (SD = 6.24 years) and a mean Vipassana experience of 1567 hours (SD = 404 hours).

The Vipassana meditation group was substantially underrepresented due to extreme recruitment difficulties, leading to the study being underpowered. Though one ideal form of the study would have compared multiple, specific mindfulness-based meditation traditions, predicted recruitment challenges compelled me to compare Vipassana to a group of non-Vipassana traditions. But these recruitment challenges and the limitations they imposed did not represent a substantial theoretical obstacle, as the amorphous nature of the meditation practices of the heterogeneous group matched a tendency in previous research to group all mindfulness techniques and traditions into one broad research category.

Though gender is a potential confound in any pain study, it was impractical to exclude participants on the basis of sex. Anyone with meditation experience in the range of one to one-hundred hours in a tradition outside of Goenka-style Vipassana was also excluded in an attempt to match the meditation groups' levels of meditative experience. There were no exclusions based on ethnicity.

Procedure

Following informed consent, I gave the participants in each meditation group a questionnaire that I developed to determine the nature of the meditation technique practiced and the level of experience of the practitioner. Non-meditators also filled out the questionnaire to ensure that they had no meditative experience.

I then gave participants an overview of procedures and an explanation of each Likert scale (one for pain rating and one for distress) that would be used after each Cold-Pressor Task (CPT). In the instructions I directed participants to "allow their minds to wander" during the set-up and initial CPT. I then explained what each group should do during the ten-minute interim period between CPTs. The control group was told to allow their minds to wander and to keep their eyes closed throughout the interim period and the second CPT. The meditation groups were instructed to begin their meditation practice at the beginning of this interim period and continue the practice throughout the second CPT, ending the practice only at the end of the CPT when they would fill out the second set of Likert scales.

Participants were then hooked-up to a heart rate monitor and a galvanic skin response sensor. I explained the purpose of each of these devices to participants and gave them time to ask any questions regarding their use. Participants then submerged their right hands into a tub of room temperature water for two minutes. They then moved their hands to the cold-pressor water (5 °C) and were directed to remove their hands when the cold sensations were too unpleasant for them to continue. I followed the convention of limiting the duration participants had their hands immersed in the cold-pressor to five minutes, though I did not inform the participants of this limit. After participants removed their hands, they were directed to indicate their pain rating and level of distress verbally

to me while looking at the two printed Likert scales held in front of them. With each participant's permission, I dried their wet hands with a paper towel and then repeated the instructions for the ten-minute interim period. At the end of that period, I gave a verbal cue for the second CPT task to begin. After completion of the second CPT, each participant was questioned as to any continuing distress or discomfort experienced. After this portion of the study was completed, I unhooked each participant from the heart rate and GSR monitors and conducted them to a lab space where the phenomenological interviews took place.

Apparatus and Questionnaires

Cold-pressor

The cold-pressor device used was a Thermo Electron Corporation (Newington, NH, USA) Neslab RTE17 refrigerated bath circulator (60.0x28.9x47.9cm). The cold-pressor method of experimental pain induction has been widely used and has proven to be remarkably safe, for both adults and children (Von Baeyer, Piira, et al., 2005). The water temperature was set at 5°C. The heart-rate variability monitor used was the Biopac Systems MP 150 with ECG module 100C and GSR module 100C.

Meditation Questionnaires

The meditation questionnaires were designed to ascertain the experience levels of the meditators and to provide initial basic data pertaining to the style of meditation practiced. Participants were asked to choose from eleven mindfulness traditions the tradition that constituted their primary and secondary (if applicable) forms of practice. They also answered questions about the time and frequency of their practices.

Likert Pain Scales

The Likert pain scales employed in this study are conventional and widely used modalities to measure self-reports of painful stimuli (Carifio & Perla, 2008). The pain rating scale measures how intense the painful stimulus is to the participant, with scores ranging from one to ten. The pain distress scale measures the level of anxiety that the participant experiences in response to the painful stimulus, also ranging from one to ten, with one being no anxiety and ten being "the highest distress/fear/anxiety I have ever felt".

Data Analysis

Neurophysiological Data

I processed the Heart Rate Variability (HRV) data using Biopac Acq*Knowledge* 5.0 Software. This followed a visual inspection of the data which revealed the need to clip the first and final three seconds of each HRV epoch due to the introduction of a possible artifact. This artifact resulted from brief interference with the sensor attached to right collarbone when the subjects moved their hands from the room temperature water to the cold-pressor tank to begin each cold-pressor task, and again when they removed their hands at the conclusion of each task.

Galvanic Skin Response data were also processed using the Biopac Acq*Knowledge* 5.0 Software.

I further processed data in preparation for analysis by calculating the percentage change from the first cold-pressor task to the second in the measurement of three neurophysiological indices (pNN50, Sympathovagal Balance, and Galvanic Skin Response) and three psychological/behavioural indices (Pain Tolerance, Pain Rating, and Pain Distress). These data points were then subjected to a Square Root, Arcsine

Transformation in an effort to normalize their distributions. These transformed data were then analyzed using two Robust Independent Samples T-tests, the first to compare non-meditators to a composite group of all meditators (Vipassana and non-Vipassana) and a second to compare Vipassana meditators to non-Vipassana meditators.

Due to a small sample size I was forced to include two outliers each in the sympathovagal balance and pNN50 data. These data sets were Winsorized by replacing the two outlier data points with a value of 1.57 which is the maximum allowed by the Arcsine Transformation method.

I chose to run two Robust Independent Samples T-tests in lieu of an omnibus test in part because my study was underpowered. An initial estimate of effect and sample size based on Liu et al. (2012) revealed that—for the purposes of detecting a group effect on my primary measure (post-intervention pain tolerance)—a total of 45 participants (N=45, n=15) would yield a power of .81, whereas a total of 69 participants (N=69, n=23) would yield a power of .95. As recruitment proved to be substantially more difficult than I had anticipated, I was able to recruit only 3 Vipassana meditators and 8 non-Vipassana meditators, giving me a total of 23 subjects, far fewer than the 45 to 69 participants that I had sought to recruit. For this reason, I was forced to engage the back-up plan that was approved during my proposal meeting of primarily comparing two groups, meditators and non-meditators. In an effort to preserve the original intention of the study I also did a second analysis that compared the two meditation groups. Because both my primary and secondary analyses were focused on directly comparing two groups, it seemed the simpler, clearer, and more direct method to utilize Robust Independent Samples T-tests

which further corrected for any violations of the assumption of normality as well as for unequal variance.

I also ran an Analysis of Covariance to isolate the effect of group difference on sympathovagal balance (the ratio of low-frequency to high-frequency heart rate variability) from any impact that pNN50 (an index correlated to high-frequency heart rate variability) might have.

Interpretive Phenomenological Analysis

Though the basic orientation of the qualitative dimension of the study is rooted in the method of Interpretive Phenomenological Analysis (IPA), the specific technique I used to analyze the data was adopted from the one systematized by Braun and Clark (2006, 2019, 2022) for Thematic Analysis. This technique provides a specific and often detailed set of procedures for conducting qualitative analyses that are compatible with the general goals and method of IPA. It comprises six specific steps, each of which I followed in performing my analysis (Braun & Clark, 2006).

The first step was to transcribe each of the interviews and to thoroughly familiarize myself with each one. The second step was to generate codes for every relevant statement by the subjects and to collate and refine these codes in order to generate superordinate themes with which to organize them. After generating the themes and organizing the statements and placing each of them into the appropriate thematic category, I made a thematic map that visually represented the basic organizational structure of the data—the specific themes and sub-themes into which each data point had been placed. The final steps involved refining and editing the themes and sub-themes and

presenting the data from each in the form of a narrative that abstracted and summarized their salient features.

My primary goal in this analysis was to explore several specific research questions related to my study's hypotheses. These questions guided the process of generating codes and the themes and sub-themes with which to organize them. The first question to be explored was what each subject did during the cold-pressor tasks as a method of distraction and/or the meditative technique they used to deal with the discomfort, as well as what each subject did during the ten-minute interim period. The second question centered on what each subject experienced during the various elements of the study, or more pointedly, how each subject understood his or her experience and how the subjects attempted to describe those experiences. As with the neurophysiological data, in the qualitative analysis I was especially interested in any experiential changes from the first cold-pressor task to the second. The final research question concerned the specific physical sensations that each subject experienced, especially those in the immersed hand. During the interviews it was this question in particular that occasionally led to the utilization of a technique derived from micro-phenomenological interviewing and analysis. Micro-phenomenology is a technique developed by Claire Petitmengin (Petitmengin & Bitbol, 2009) and further systematized by her and others that seeks to uncover and explore detailed aspects of a person's lived experience (Petitmengin et al., 2018). Part of the technique involves the recapitulation by the researcher/interviewer of the subject's description of her experience in an effort to facilitate an iterative process in which the subject is able to correct any misconceptions that the interviewer might have and that enables both to dig more deeply into the subject's experience.

RESULTS

Neurophysiological Data

In the following analyses, the independent variable is group, consisting of two levels (meditator [Vipassana and/or non-Vipassana] or non-meditator), and the dependent variables are pain tolerance, pain rating, pain distress, sympathovagal balance, pNN50, and galvanic skip response. Table 1 shows the means and standard deviations of each of these measures, with the recorded values reflecting the percentage change from the first cold-pressor task to the second.

Table 1

Descriptive statistics for study variables separated by group (Meditator, Non-Meditator, Vipassana Meditator). All Mean and Standard Variation values reflect percentage change between the two cold-pressor tasks.

	Group	Tolerance	Pain Rating	Pain Distress	SVB	pNN50	GSR
N	Meditator	8	8	8	8	8	8
	Non-Meditator	12	12	12	12	12	12
	Vipassana Meditator	3	3	3	3	3	3
Mean	Meditator	0.368	-0.118	-0.168	0.954	0.309	0.0527
	Non-Meditator	0.260	0.0352	0.00220	0.0765	0.235	0.0596
	Vipassana Meditator	0.434	-0.0276	-0.0817	0.511	-0.118	-0.0340
Standard deviation	Meditator	0.282	0.125	0.138	0.568	0.554	0.188
	Non-Meditator	0.384	0.122	0.115	0.374	0.675	0.189
	Vipassana Meditator	0.600	0.190	0.241	0.965	0.0279	0.213

A primary hypothesis of the study was that the change in pain tolerance would be significantly higher for the meditators than for the non-meditators. A Robust Independent Samples T-test, however, revealed no significant difference between non-meditators and the composite group of meditators (Vipassana and non-Vipassana combined), t (12.58) = 1.194, p = 0.25. GSR likewise showed no significant difference between groups, t (11.86) = 0.282, p = 0.78, strongly indicating that there were no substantial changes in the initial, brainstem-centered, automatic response to the cold-pressor tasks as a function of meditative practice compared with no meditative practice. Finally, in my chosen measure of HRV that correlates to high-frequency heart-rate variability, pNN50, no significant differences emerged between the two groups, t (12.22) = 0.267, p = 0.794.

On measures of sympothavagal balance (SVB), however, my analysis revealed a significant difference, t (6.69) = 2.985, p = 0.021, which indicates more substantial neurophysiological changes in the meditators than in the non-meditators. A follow-up analysis of covariance (ANCOVA) performed in an effort to isolate the impact of group difference on SVB revealed a significant effect on SVB based on Group after controlling for the effect of pNN50, F (2, 20) = 10.77, p = 0.004. The effect of pNN50, the covariate, on SVB was insignificant, F (2,20) = 0.006, p = 0.939). These results strongly suggest that changes in SVB arose predominantly from changes in low-frequency heart rate variability, which is mediated by a complex interaction of parasympathetic, sympathetic, and baroflex activities. This potentially runs counter to the prediction I made that meditators would show increased activation of the parasympathetic nervous system compared with non-meditators.

In the two psychological indexes, meditators showed significant reductions in their ratings of pain intensity, t (8.17) = 2.49. p = 0.037, and pain-related distress, t (9.56) = 4.46, p = 0.001, compared to non-meditators. This aligns with previous studies that have demonstrated the utility of meditation in attenuating the experience of pain through a complex process of cognitive reframing (Gard et al., 2012; Zeidan et al., 2011).

A comparison of dependent variables between Vipassana meditators and non-Vipassana meditators using a Robust Independent Samples T-test showed no significant differences between the two groups on any index. This potentially disconfirms my predictions that Vipassana meditators would show substantial differences in each of these measures, especially in pain tolerance. But the present study is substantially underpowered and the results, though likely to hold in a study with a more robust sample, must here be considered inconclusive.

Interpretive Phenomenological Analysis

As described above, I performed the Interpretive Phenomenological Analysis using the specific procedures of Thematic Analysis systematized by Braun and Clark. In the process two superordinate thematic categories emerged: Distraction Methods and Meditative Practice was the first; Experiential Qualia was the second. Distraction Methods and Meditative Practice was further divided into the sub-themes of Distraction/Meditation Techniques, which focuses on the various ways that non-meditators attempted to distract themselves from the painful stimuli of the study and the specific techniques that meditators used to do the same; and Self-Evaluation, in which subjects revealed their judgments about their performance on the cold-pressor tasks. Experiential Qualia was divided into the sub-themes of Sensational Shift, which focused

on the specific somatosensory phenomena the subjects experienced, and Perceptual Shift, which focused on how the subjects perceived the intensity of the painful stimuli. Perceptual Shift was further sub-divided into the categories of Expectation and Intensity. For each thematic category I have described the results for the non-meditation group followed by the meditation groups and have highlighted any substantial differences between the meditators and non-meditators or between the Vipassana meditators and the practitioners of other meditative techniques/traditions. When appropriate I have also demarcated the results based on cold-pressor task.

Distraction Methods and Meditative Practice

Distraction/Meditation Techniques. One substantial and self-evident difference between the meditators and the non-meditators was in whether distraction techniques or formal meditative techniques were employed to attempt to deal with the cold-pressor pain as well as when those techniques were used. For the non-meditators a variety of distraction methods were utilized, and any shift that occurred between the first cold-pressor task (CPT I) and the second (CPT II) seemed largely the result of non-conscious processes or an impromptu process of trial-and-error.

For the non-meditators the most common distraction methods were to observe various objects in the room, to think about things that they needed to do or to focus on that day or in the near-future, or to pay attention to their breathing. In two cases, the distraction methods of thinking about school and looking around the room were consciously employed during CPT I:

> Subject 21 (S21): When I wasn't thinking about anything my hand was on my mind. So I would just, like, try to read or count stuff.

Tim: Okay. What were you counting?

S21: The buttons on the thing [remote control device]…And then I was also looking at that paper on the wall.

Subject 20 (S20): Really just not focus on the water. Try to think of something else.

Tim: What were you thinking about? Generally speaking.

S20: Probably school. School.

For most of the non-meditators, any distracting activity employed during CPT I took the form of the mind wandering but was not employed as a conscious way of distracting from the cold-pressor pain.

For S12, the initial pain took his entire focus, but after the first wave of discomfort was endured, thoughts of "day to day things" began to occur and his "mind just started to wander." More commonly, the pain of CPT I was so consuming that the subject's attention was fixated on it, and no conscious attempt at distraction was attempted. S2 described entering a "fight or flight type [feeling], like, more attentive to like, what was happening." S10 put things bluntly: "I was kind of like, holy shit, and that was about it."

For nearly all of the non-meditators the conscious attempt at distraction began mainly during the ten-minute interim period when there was no painful stimulus to attend to and nothing else to occupy their attention. In some cases this was largely an effort to combat boredom. S2: "I was just chillin but it did feel like a long time. I started like reading all the little, like anything I could find in the room to like…I don't really sit for

ten minutes and do nothing." S12 described thinking about things she needed to do later in the day as a way to distract from how long the ten-minute interim seemed to be taking. S21 shifted her attention in response to boredom: "[I would look] at most, a minute because then I would, I would get bored, and I would look at something else." For other non-meditators the distraction method was employed as a way to deal with anxiety arising from the anticipation of CPT II. S4: "I pretty much just focused on just different stuff on work, and just trying to get my mind off it [CPT II]…Because I knew my anxiety level would get higher." Still others used a trial-and-error method to deal with anxiety arising from the study participation as well as from initial attempts at distraction. S17: "And then it [a to do list] didn't make me feel super calm. I was like, I'm supposed to be calm right now. So then I started thinking of other things…" S18 began to get anxious at not being able to do the items on her to do list and shifted to looking around the room.

The distraction methods that the non-meditators employed during the interim period were often employed during CPT II as well, though with mixed results. S2 describes the shift from CPT I to CPT II: "Yeah, like the first time [CPT I] I was trying to understand it, and then try to focus on it. And the second time, I was, like, trying to distract myself." S8 used the observation method of distraction along with a unique method of singing to himself, a technique that had limited success: "Honestly, I was singing to myself in my head to, like, distract myself and I was, like, I can't do this much longer." For S9 the ten-minute interim provided an opportunity to think about "a lot of things" which "emptied my mind" and allowed her to more calmly observe the painful sensations of CPT II without reacting as strongly as she had during CPT I. S10 shifted her distraction method from thinking about an upcoming exam during the ten-minute

interim to focusing on a specific point in the room during CPT II and was able to maintain that focus for nearly the entire five minute period: “I think I lost focus for like a split second. But otherwise, I was just staying in there.” In response to why she did not try and use a similar technique during CPT I, she explained that it was probably due to “not knowing what to expect. A lack of focus…Just kind of going in there, like, well alright, let’s try this thing out.” S17 used a visualization technique for CPT II that was rooted in imagining the things she would do in an upcoming trip to her hometown of Houston. This technique allowed her to very successfully distract herself from the pain by “just not being here anymore.” In an effort to keep their hands submerged during CPT II, both S18 and S19 shifted distraction techniques midway through. For S18, as the painful sensations became more intense and as the method of looking around the room failed to distract her, she shifted to counting: “And so, when it was kind of overwhelming enough, I was like, okay, well let me just count. You know, how many more seconds can I keep it in. That was my strategy.” S19 attempted a breathing technique during the interim period that she abandoned in favor of the distraction method of thinking about finals and which shifted again with CPT II into thinking about “my life…all the stuff I’ve done. And this is where I am now. What am I going to do in the future?” This technique was further refined by focusing on a single point which enabled her to maintain her concentration on her thoughts and better block out the pain of CPT II.

Four non-meditators specifically used a focus on breath as one of their distraction methods during CPT II. The various techniques employed showed substantial overlap with some aspects of the formal meditative techniques utilized by the mediation groups. During the ten-minute period, S8 “tried to prepare myself, focus on breathing more,

trying to distract myself more." His technique of "breathing through" the pain was utilized during CPT II in conjunction with other techniques such as singing and focusing on objects around the room. S10 described employing a breathing technique that she had learned during a bad relationship in the past when she had needed to "remain calm" and "not freak out:" "So, I think it was just more of that, just my breathing technique from that, just learning to calm myself down." S20 began to focus on his breath during the ten-minute interim and maintained that focus for three or four minutes until his mind was calm and his body had relaxed enough that he could stop focusing on his breath and let his mind wander. This felt to him like a "form of meditation" though "he hadn't really meditated" before. He seemed pleasantly surprised by the state this aroused in him and that was maintained through much of CPT II. When asked to describe this state, he responded that it was like "not really having running thoughts. Not really focusing on something or worrying about something or expecting something. Just straight serene."

Like the non-meditators, the subjects in the meditation groups used a variety of techniques to help them deal with the cold-pressor pain. One meaningful difference between the meditators and the non-meditators could be seen in their reactions to CPT I. As noted, the non-meditators did not typically employ a distraction technique during CPT I. The meditators, on the other hand, tended to use distraction techniques as a way to deal with the painful stimulus and as a way to keep them from engaging in the meditative practices that they were instinctively inclined to engage in. They had been instructed to not utilize their meditative techniques during CPT I, and most meditators found this challenging. In response, many resorted to the same sorts of distraction techniques that the non-meditators employed during CPT II. S3:

So I was trying to like, not be mindful, but also that naturally just kind of happened a little bit…And then towards the end of it, I felt like I was doing good at being able to not be too mindful about stuff. Just thinking through, like, the things I need to get done today. And, then it kind of settled where it wasn't too bad.

S6:

I was told to deliberately not try to do the things that I would normally try to do in the first one. And I was successful at doing that. I didn't do any breathing. I mean, I breathed, but I didn't focus on my breathing or anything like that…it [the cold-pressor task] was much easier the second time.

S7: "…it was a shock in the sense that I knew that I couldn't use any of my techniques. So, I had to, like, space out. And it…made the pain more unbearable than it would normally have been for me." S13: "I was trying to distract myself, just look around the room." One of the best descriptions of the difficulties faced by meditators during CPT I was voiced by S15: "The first round was sort of a challenge to not immediately start meditating because it's [the mind] habituated to that. And I think I tried humming quietly or trying to do something that was not a meditation practice…it was almost like an anti-meditation meditation."

The mediators used a variety of techniques during the ten-minute interim and CPT II, though a common element was attention on the breath, a technique that nearly every meditator used. For some this took the form of a preparatory or supplementary practice. S3 used breathwork as a method for transitioning into other practices: "Yeah, so I started focusing on the breath, and then I kind of just naturally started…practicing, like, just metta, like, loving kindness for myself." This eventually transformed into shifting

attention to sensations in the body and to passing thoughts, but attention consistently returned to the breath. S7 used deep breathing along with visualization techniques. She described the way she used the breath to maintain her meditative practice in the first moments of CPT II: “It was like that shock, like, okay, yeah, that’s right, I have to continue to maintain this. And it took me, like, fifteen good breaths to finally make, bring back to that, that…color.” For many other meditators attention on the breath constituted the primary focus of their practice. This was especially true of the two long-term Zen practitioners. S6 maintained a focus on the breath by counting each breath in cycles of ten. S15 described his practice as “a physical sensation of breath” and explained that “it’s about feeling it down in the belly, you know, chest, sometimes focusing on the physical sensations of the nostrils. But it’s very much just about the awareness of the physicality of breathing and making sure to breathe fully.” For two of the Goenka-style Vipassana meditators, breathwork (Anapana) constituted the beginning of their practice, and when they attempted to shift into the body scans that are central to this tradition, they had difficulties that compelled them to focus primarily on the breath. S5 described the process: “Start with Anapana, just breathing through the nose, focusing on the nose sensations. Do a little bit of body scanning from the top of the head down to the shoulders.” Eventually this led to trying to observe sensations throughout the body, but this, in turn, led to “getting lost in thought so I thought, I, let’s reel it in and just do the nose breathing.” Another Vipassana meditator, S23, had a similar experience: “Just literally, I did body scanning. And then I noticed I was starting to drift a little bit, so I focused more on my breathing.” S22 used a breathing technique called the big four (four counts each for inhalation and exhalation and four counts holding the breath before each

inhalation and exhalation) that he learned in the military and which he combined with a focus on relaxing the body and occasional shifts into metta practice. His primary focus during CPT II became the quality of the breath: “But once I kind of get to the point where my mind is calm, and I know it’s the breathing that will lead to that, I know I’ve had a good breath.”

For two meditators, focus on the breath played no part in their practice. Surprisingly, one of those was a Vipassana meditator whom I had expected would start with Anapana as a way to focus the mind. Instead, S5 immediately began with Vipassana-style body scanning: “So yeah, so I was just doing a Vipassana meditation, you know, moving my awareness through my body, feeling sensation, as we say, from head to toe, toe to head; from head to foot to head.” He was the only Vipassana meditator who was able to maintain the body-scanning practice throughout the ten-minute interim as well as during CPT II. S13 used a chanting technique in which she would repeat the syllables SA, TA, NA, and MA using different vocal frequencies and different volumes. Though she did not specifically focus on the breath, these changes in the quality of the vocalizations compelled a background awareness of how she was breathing and the quality of each breath. At one point she felt a bit breathless and shifted to reciting the syllables in her head: “And I felt a little out of breath with some of these, like, I couldn’t quite get a whole inhale…And then I was saying the same sounds in my head, and breathing kind of smooth and deep as I said the sounds in my head.”

For several meditators, breathwork played a supplementary role in a complex progression of meditative techniques. During the ten-minute interim, S3 began with a focus on the breath and added a mantra that was recited internally in conjunction with it:

"[I] brought my attention to the breath. And I have just like a mantra developed, which was like, there is a body and it's breathing." This dual focus on breath and his particular mantra led to a sense of dissociation of attention from the body, a dissociation that was consciously maintained. This dissociated state shifted into a metta practice that was initially directed toward himself but that was then consciously expanded to include others. Throughout the interim period and CPT II, S3 shifted between attention on the breath, metta practice, bringing attention to the body, or allowing an open awareness to arise that shifted attention to various sensory modalities. S7 utilized several techniques together in a sophisticated practice developed over many years that was specifically designed to help her deal with chronic pain. For her, different breathing patterns were utilized depending on the type and intensity of pain along with humming at different frequencies. Both of these in turn influenced a visualization technique that was focused on maintaining a "blank state" internal visual field, one whose color shifted: "Before the humming the colors changed…Sometimes it was blue. Sometimes it was purple. Sometimes it was like a deep maroonish black. And then once I started humming, I was able to keep and maintain a specific color…it was white, like off white, like a creamy white." Within this blank slate wall of white, she was able to focus on one point and successfully maintain that focus throughout the ten-minute interim and CPT II.

Self-Evaluation. One motivational technique that was common to both the meditators and the non-meditators revolved around a set of practices or orientations that I've categorized as self-evaluation. Among the non-meditators this often took the form of an initial curiosity during CPT I about how long they would be able to keep their hands submerged. After the initial shock of feeling the cold water, S4 thought "…okay this is

going to be interesting. So, I said, let me just leave my hand as long in there as I possibly could without, like, it being too painful." S8: "[I] was kind of thinking about, like, how long it's been and, like, how much longer I'd be able to keep it in." For many non-meditators this curiosity could shift into more of a motivational tendency. S17 describes the impulse succinctly: "Like, just motivationally—just a little bit longer. Just a couple more seconds, okay? Like, just pushing myself." S20 similarly described thinking, "Let me go another sec." Later, S20 demonstrated another shift that this motivational component could take: "I guess I was mentally wanting to last longer than I did the first time." Similarly, S8 later described doing a breathing exercise during the ten-minute interim "mainly to see if I could last longer with my hand in the water [during CPT II]." This competitive spirit was seen in many of the non-meditators and was almost always self-directed. It manifested as a pronounced desire to perform well during CPT I or as a desire to perform better during the second cold-pressor task than they had during the first. S10 exemplified both competitive impulses. During CPT I, she motivated herself aggressively: "And then I kind of thought, like, okay, am I just being a little chicken? You know about this! And then I was like, okay, just try to stick it out." Later, in describing her attitude during CPT II, she said, "I guess I have, like, a competitive spirit about me. [I was] just more focused on not getting out as fast as I did the first time." S19 describes setting a goal for herself for CPT I that she failed to meet. For CPT II she was even more determined: "Oh, the second time I was like, this sucks, but I really want to, like, beat my own time." Perhaps the fullest and most imaginative expression of this competitive spirit was shown by S16. She described CPT I as "basically, like, a competition against myself to see, like, if I was submerged in cold water, would I

survive? And then, like, this hand…my hand can take it kind of thing. And after a little bit I was like, maybe not." Later she described CPT II as a "life or death challenge, like Survivor, or something." She also described wondering about her heart rate readings and wanting to "relax my heart rate so it looks like I have no… like a total badass—no cold reaction."

Many of the meditators showed similar tendencies of self-evaluation. S23 described being confident that she could last much longer during CPT I than she did. "I was a little disappointed that I couldn't do it just because I felt like I did have a relatively higher pain tolerance." S5 expressed the desire, during CPT II, to "just make it as long as I did last time." S22 described pulling his hand out during CPT I almost immediately after wondering how long he would last. "So, it's just kind of how long am I going to do the, you know…I…that's about all I can handle." Like the non-meditators, curiosity and motivational tendencies could become more competitive. S3 described his initial feelings during CPT I: "I think it was more of like, competitiveness. I was wanting to, like, I wanted to, like, prove to myself, like, you can keep your hand in this thing, you know?"

Though there were similarities between the meditators and non-meditators in how the self-evaluative mechanisms manifested, there were also marked differences. One of these was the tendency among the meditators to wonder about how other people had performed on the cold-pressor tasks or might handle similar types of pain, a tendency not seen in the non-meditators. S6: "And I remember thinking to myself, how long do people keep their hand in this water." S5 also wondered, "how long other people are lasting in this water." This basic curiosity about the experience and performance of others could manifest in interesting ways. S3 found that the experience of pain made him feel

connected to other people in the world and made him feel grateful to "tap into that human experience" which transformed the pain of CPT II into something "very sweet, and also kind of exciting." He reiterated this idea later in the interview when asked to explain how his motivations had changed from CPT I to CPT II:

> Tim: Describe…your mental process that sort of led you to just stay with it [during CPT II].
>
> S3: Yeah, it sounds…maybe sounds weird, but honestly, it was like compassion. It was just like, the awareness that, like, a lot of people feel pain, a lot worse pain than this and a lot more frequent than this. So, like, again, like I get to be a part of that human experience.

Other meditators drew inspiration from thinking about practitioners in their own or different traditions. S15 described being reminded of sitting with other meditators during long Zen retreats where each practitioner faced Zen-style encouragement to maintain their posture: "And, you know, in the Zen tradition, there is an emphasis of, please don't move. Or sometimes in the Japanese…in the more Japanese styles, it's like don't move or we'll hit you with a stick." When the discomfort was becoming difficult to bear, S22 found motivation in "this vision I'd seen, you know, a series of Tibetan monks, and the robes, and they're sitting in the snow."

These last two examples also point to a final difference between the non-meditators and meditators in terms of self-evaluation. In short, the meditators know that meditation is supposed to help them deal with pain. This represents a substantial confound for this study, and the signs of it were both overt and subtle. S6 openly discussed this: "…okay, well, I know what he's testing. One of the things he's testing

here is the effect of the intervention on the, on the post-performance. And…I'm interested in that too. And so, I would say to myself, okay, so if the meditation practice is useful, then I'll be able to keep my hand in longer." S15 expressed his awareness of what was being measured when asked about the sensations he experienced during CPT II: "Yeah, it's probably the heart of what you're trying to get at in the study." These overt signs of conscious awareness of what the study was measuring (and what the hypothesized outcome was likely to be) were not typical. However, these coupled with the comparisons that were made to Tibetan monks and Zen practitioners point to an underlying sense that meditation increases one's ability to endure discomfort, an impression that the meditators were more susceptible to than the non-meditators. This impression could manifest in subtler ways than in those already described. S23 describes an aspect of her experience during CPT II. "I think I was more fascinated if anything about…I was like, one, I know for a fact I have been in here longer than I was the first time. So, I thought that was kind of cool." This is not necessarily problematic but it points to the fact that meditators want their meditative practice to "work" and they have an underlying sense of what that means. Unfortunately, I did not sufficiently address this issue in my interviews, a mistake I am resolved not to repeat in any future studies of this sort.

Experiential Qualia

Perception and the Perceptual Shift. The examination of the subjective experience (qualia) of the subjects revealed two dominant perceptual themes: expectation and intensity. Though these two facets of experience are distinct in some ways, the perception of the intensity of painful stimuli was often directly impacted by the subject's

expectation, especially before each cold-pressor task. It is useful, therefore, to look at the two together.

Perceptual intensity itself is difficult to define. Rather than attempt to do so here, I will let the subjects' descriptions of their experiences give a sense of what is being conveyed with the term. I will also separate the analysis by cold-pressor task as there were significant differences in subjects' experience of expectation and intensity between the two. In my examination of the first cold-pressor task, I have not separated the data between meditators and non-meditators as there was not a significant difference between the two groups.

The First Cold-Pressor Task. The interplay between expectation and intensity is seen most clearly in the initial reaction nearly every subject had to putting their hand in the cold water for CPT I. The most prevalent term used to describe this experience was shock and the cause of the shock was often how much colder the water was than the subject had expected: S2: "It felt like shock a little bit…like, oh shit, this is a lot colder than I was expecting."; S8: "It's kind of shocking, colder than I thought it would be. Like, like an ice bath."; S9: "…initial shock…"; S10: "It was a shock…"; S12: "It was shocking, much more cold than I thought…"; S16: "It was kind of an immediate, like, shock at first."; S18: "Um, shocking at first…"; S20: "It was a shock…"; S6: "…it was a lot more painful and cold than I anticiptated…It was shockingly cold…"; S7: "…it was a shock…"; S13: "It's kind of, kind of a shock." Even for those subjects who were expecting the water to be cold, the initial experience of it could be shocking. S19 describes expecting it to be like "when you go to, like, a river or something and it's all icy, and you put your hand in it…It was like that but a lot colder than I thought it was

gonna be." S7, a meditator, also expected the water to be cold but found the experience shocking for a different reason: "…even though I was expecting cold water, um it was a shock in the sense that I knew I couldn't use any of my techniques."

Even when subjects did not find the initial experience of immersing their hands in the cold-pressor water shocking or unexpected, they almost always described the intensity of the pain as progressing rapidly. S3 described the process of going from feeling surprisingly relaxed at the beginning of CPT I to "the point where it got pretty intense…" and "peaked a little bit." S5 also described a rapid progression of the pain: "Yeah, I mean, it wasn't surprising. There was no shock to it, but it just got, it got painful quickly." The experience of S15 was similar: "If I had an expectation, I would say that the moment of plunging it in, it seemed less uncomfortable than maybe I expected, not dramatically so, but then within a few second, it started feeling quite uncomfortable." S17 experienced a dramatic increase in the intensity of her pain: "It wasn't as bad at first, and then it got worse and worse and became intolerable, I suppose." This progression of the painful sensations to a point of intolerability was well-described by S23: "It hurt really bad. It stung for a little bit. And then there was a point where I thought I wouldn't feel any more pain, but then it still kept going on and going on, and that's when I was like, okay, I should stop this right now." This was a common pattern for both the meditators and the non-meditators. Regardless of what their expectations had been before beginning CPT I, nearly every subject described a rapid progression of the intensity of the painful stimuli.

For most, this progression continued until they felt compelled to pull their hands out of the water, as described by S23. For others the intensity stabilized and the pain

became tolerable. S21: “It was cold at first. Like, that doesn’t mean, I mean, pain. And then it started to, like, go down. And then, and I was just debating whether I should take my hand out or not. And then after that was fine.” S3 described the pain becoming “pretty intense” and growing increasingly sharp until a point “when that peak in those locations was when I was probably the peak of the distress and the peak of pain.” After the peak was reached for S3, the intensity of the experience subsided: “Yeah, and then it kind of settled where it wasn’t too bad.” S12 experienced the cold as shocking and felt the pain increase rapidly until he reached a point of stabilization: “So, it slightly got worse and worse until to a point it just stopped.” He continued to feel sensations of cold but the intensity “just kind of stayed there.” During this period of stabilization, the painful sensations would occasionally “spike up” and get “a bit more intensified.” S11 described a slightly different cycle in which the initial sensations of cold morphed into feelings of warmth and then numbness and returned to the initial cold sensations “but [weren’t] as cold as when [I] first put it in.” Afterward a less intense form of numbness returned and a “stability level…was achieved.” It is important to note that each of the four subjects who describe a stabilization or leveling-off of their pain and/or distress kept their hands in the cold-pressor water for the maximum allowable timespan of five minutes. They were the only four to do this during CPT I though there were several more who endured the entire five minutes during CPT II. Of the four who did this the first time, two were meditators (S3 and S11) and two were non-meditators (S12 and S21).

The Second Cold-Pressor Task. Expectation took on a different cast in the lead-up to CPT II. Whereas subjects did not know entirely what to expect as they began CPT I, the common experience of shock indicates that they did not expect the water to be as

cold as it was. As CPT II began, each subject seems to have developed a schema for what was about to happen and what the experience was likely to be. For half of the non-meditators this provoked anticipatory anxiety which often intensified their experience of pain compared to CPT I. S4 described her anxiety peaking when she knew that "the pain was imminent" and this provoked a "fight or flight response…Then I said, okay, this is gonna be bad, but then it got worse." S12 described a similar experience in the lead-up to CPT II: "That's when my anxiety shot up. That's when my body knew what was going to happen and didn't want to go through it again." This led to the experience of the pain being more intense: "Yeah, everything felt more intensified and I think that is because of the anxiety." S19 described her anxiety increasing as soon as she put her hand in the room temperature water in preparation for CPT II: "Like, right before I put it in there, when it was in, like, the bowl, I was like, this is gonna be worse because even, like, the bowl before hurt…this was going to hurt worse. Okay, so like, I immediately went into it with pain." S20 immediately felt the painful sensations of CPT II as more intense and explained why she thought that had been the case: "I think they probably were only because I was hyping myself up in my head. I know it's gonna be cold. It's gonna be cold. So, I do think it was probably a little more intense." S21 experienced something similar: "I only knew, like, it was going to be cold because I felt it before. So, I already knew what I was getting into. The pain was, I think, worse than the first time."

Several non-meditators reported no increase in anxiety but each reported that the pain was more intense and progressed more rapidly than during CPT I. S9 reported feeling little anticipatory anxiety which led to some initial shock that paradoxically didn't bother her too much at first: "That's why when I put it back in I didn't feel much initially

but it escalated a little bit quicker than before. I felt like it felt a little bit more intense." S16 described feeling confident that since she'd experienced the task once before it wouldn't be as bad the second time:

> I think it was a little more dramatic than the first one because I kind of went into it expecting, like, thinking it was okay; I did it already. So, it's not that bad. Okay, but I feel like it was even colder, like everything was heightened…

S17 began CPT II in a very calm state because of the method of distraction she employed during the ten-minute interim. Even so, the intensity of the second cold-pressor task surprised her: "Oh my goodness, um, it felt cold faster. Like, I felt like I hit my peak or close to my peak a lot sooner."

For a final subset of non-meditators the experiential schema they had developed for CPT II reduced their anxiety which in turn reduced the intensity of their experience of pain compared to CPT I. S2: "It was very, like, this isn't as bad. Like, I already know what this feels like. And it doesn't feel as, like, crazy." This reduced intensity was maintained until she experienced "novel" sensations of numbing that made her "feel more anxious because, again, it was like, oh, this is a new feeling." For two non-meditators, their experiential schema seems to have allowed them to better prepare for CPT II which reduced both their anxiety and the initial intensity of the pain. S8: "…I kind of like prepared myself a little bit more since I knew what it felt like…Focus on breathing more; trying to distract myself more." S10 felt the schema gave her the knowledge necessary to be able to utilize a distraction technique she'd developed previously:

> I guess I was knowing what to expect already. The level of pain…And I was just thinking of when I go deep sea fishing, like, you suddenly get seasick. You just

try to find something and focus on it…And so that's the method I took was, well, let me just focus on this glare on the button. And then I just, I just stayed there.

Though expectation and intensity levels were similar for the non-meditators and the meditators for the first cold-pressor task, there were significant differences in both experiential measures for the second. Of the meditators, only S3 reported anxiety in the lead-up to CPT II: "And then at one point, like, I just felt just this little, like, jolt of adrenaline kind of like nervousness because I could anticipate my hand going into the cold water soon." That anxiety was quickly replaced by a sense of curiosity about how the pain would feel and gratitude at "being able to tap into that human experience [of pain]." This had a profoundly calming impact on him that, along with the experiential schema, helped reduce the intensity of the pain.

Tim: And do you think that the pain… was lessened because you were feeling

more relaxed and more grounded? Or do you think that the painful sensations were less intense?

S3: I think a little bit of both, like, I think having felt it previously and now feeling it again in a more settled state allowed, kind of allowed it to just be a more curious process than…like is this gonna get worse?

S13 started off CPT II relaxed, but when she put her hand in the water "I was a little bit tense…but it was, it was less intense right away…during the meditation, as soon as I put my hand in, it was less intense right away."

Several meditators expected CPT II to be easier because of their meditation practice. This didn't work out well for S5:

> But I was surprised to find that, you know, it started out a little bit more intense, it seemed like, so I think that sort of threw me. And then there was a moment of wondering, you know, am I a bad meditator?

For others this expectation that CPT II would be less painful proved accurate. S14:

> I imagined…that it would be less painful after meditation. Because you're a little bit more relaxed. And I think I was…And it ended up being true…It was still really cold and painful, but it didn't bother me the same way the second time.

S7 expected CPT II to be easier because she would be able to use her techniques. Even so, the initial experience "was like that shock, like, okay yeah, that's right I have to continue to maintain this [the meditation]." She was successful at doing this and was able to maintain her meditative practice at a higher level than she had during the ten-minute interim because the pain provided her "something to focus on." Eventually, the painful sensations were transformed into "butterfly kisses," and the intensity of the experience was so reduced that she would have been able to keep her hand in the water for much longer than the five minute maximum that she did.

Several meditators made no mention of tension or anxiety in the lead-up to CPT II but each of these subjects reported a reduction in intensity over CPT I. For S6 the beginning of CPT II was "less shocking because I had already entered it so I knew what to expect" and the overall experience was "similar to the first time but all a little less intense." S15 described CPT II as "still initially quite uncomfortable" but, because of his meditation practice, it "was quite manageable," and the overall experience "felt more natural to me than the first time around…" S22 made no report of anxiety or stress as CPT II began and found it "much easier to endure…" S23 began CPT II in a relaxed state

of "lightness" and found that immersing her hand the second time "wasn't worse or better that the first time in the beginning" but that she "wasn't in any sort of, like, distress…I think I was more fascinated if anything…" S11 had a very strong schema going into CPT II but it did not cause him any anxiety:

> There was a certain type of, of, just kind of experience from the first time that I kind of had already going into the second one. So, you know, I kind of knew how cold that was, you know what it was going to be. But when I had, you know, put my hand in there and basically just continued [with the meditation].

Eventually, the intensity of CPT II would be reduced so significantly that S11 reported that he "basically, [did] not have any pain at all."

Among both the meditators and non-meditators several more subjects lasted the full five minutes during the second cold-pressor task than did so during the first, with each of the four subjects who managed it the first time doing so the second time as well. The split remained even between the two groups with six meditators (two of them Vipassana meditators) lasting the full time along with five non-meditators. The experiences of these subjects were similar to those four who lasted the full time during CPT I, namely that the intensity of the experience stabilized in a way that did not happen for those subjects who pulled their hands out before the five minutes were up. S3 felt the intensity peak more quickly during CPT II, but "the drop-off from the peak was quicker also" which allowed for a more "settled" state to emerge and to be maintained throughout most of CPT II. S7 felt the pain increase until "maybe twenty to thirty breaths in, it kind of just, like, maintained. It didn't keep going up. It didn't go down." S11 described the pain and intensity as "level[ing] off," and S17 described hitting a "cold equilibrium." S19

found the sensations of pain to be intense but "more constant" during CPT II. For S12, the intensity of the painful sensations was just as intense during CPT II, but the cycle that led to stabilization occurred more rapidly: "But then again, it went by a lot quicker. Okay, like the timeline of the cold and then the prickly, and then just being okay with it."

Sensation and the Sensational Shift. The sensational experience of subjects and how that changed from CPT I to CPT II is the final aspect of my qualitative analysis. Here I was looking specifically at how subjects described their experience of the actual sensations of pain and cold and how that description changed between the two cold-pressor tasks. I was also looking at what differences I might glean between the experience of meditators and non-meditators, especially post-baseline. Apart from this general investigation of sensational experience, I also wanted to look at whether the experience of "subtle" sensations arose for any of the Vipassana meditators or any of the other meditation practitioners and what impact that might have had the subject's experience of pain. This was a secondary focus of the qualitative analysis and, as a reminder, I hypothesized that to the degree that a Vipassana meditator experienced subtle sensations, he or she would experience a change in the quality of their sensations which would lead to a diminution of the actual sensations and perception of pain.

Though I separated the analysis of perception and the perceptual shift by cold-pressor task, there was less of a need to do so with sensation and the sensational shift. Almost every subject, meditator and non-meditator alike, expressed no substantial difference in the type or quality of their sensations (as opposed to the intensity of those sensations) save for the instances when a subject kept their hands emerged significantly longer during the second cold-pressor task then he or she had during the first. There were

two notable exceptions to this that I will analyze in greater depth at the end of this section.

As for the sensations themselves, the most common descriptions were of pins-and-needles, tingles, heat, or numbness, and often some combination of these: S2: "…like needles…Like if you've gotten a tattoo, it kind of felt like that electric kind of needle feeling."; S4: "…it was kind of like pins and needles at first…"; S8: "When I first put it in it seemed kind of warm for a second…then my hand started to tingle a bit."; S9: "…my hand is growing a little bit numb."; S10: "I could feel a little warmth in my hand, but then it started to feel like, like, prickly, almost like tingly…like a diabetic prick…all over my hand."; S12: "…cold prickly feeling…like when your hand falls asleep and you have those ants feelings."; S16: "…tingly. Kind of like when the TV is, like, staticky…I feel like it was hot…"; S17: "I suppose it was tingling."; S18: "Yeah, pins and needles in the beginning. And then kind of pressure in the second half."; S19: "…it was, like, tingly right away…[then it] felt like when you get a numbing shot?...Like it burns and then it goes away. But the burn didn't go away. It just stayed there."; S20: "And my hand was kind of tingling a little bit…It felt like my hand was just getting poked with, like, needles over and over."; S21: "It was like a numbing sensation…Just, like, like, needles, I guess. Pins and needles."; S3: "…this sensation of cold feels kind of like needles, like pins and needles…"; S5: "You know, I don't know if it's hot or if I'm being stabbed by a million needles. Once you get to a million needles you're not sure what's going on."; S6: "…could have been melting, you know, could have been heat…"; S7: "Ah, it went numb, then hot, then tingling, like, almost like electric."; S13: "And then it was kind of

prickly, tingly…"; S22: "Immediate numb. Immediately numb…just stiff, sharp pain straight to numbness."

Those subjects who did describe significant changes in their sensational experience belonged almost exclusively to the group who did not last the full five minutes during CPT I but did last that long during CPT II. These subjects experienced a shift from some form of tingly sensation to the onset of partial or complete numbness. For S17, the experience of the progressive intensification of tingly sensations that compelled her to remove her hand during CPT I was the same during CPT II, but at a certain point that progression stopped and she "hit a cold equilibrium," the tingles "went away" and her hand "was numb. Like I felt it as a thing. But…[the sensations were gone]." For S13 the prickly sensations from CPT I returned for CPT II and remained throughout, but about halfway through "the body kind of relaxed a little bit and the hand almost just became numb." S23 described the same tingling and burning sensations from CPT I but they were quickly overtaken by a feeling of profound heaviness in the hand: "it was gradual, it just kept getting, feeling heavier and heavier the more I was in the water…"

The experiences of S11 and S15 were unusual and may mark the only two examples of the arising of the subtle sensations that I predicted would happen for each of the Vipassana meditators. Of those Vipassana meditators, only S11 potentially exhibited this phenomenon; S15 is a Zen practitioner and the most experienced meditator of the study. The experiences of both these subjects are difficult to encapsulate and are worth examining in some detail.

S11 lasted the full five minutes for both cold-pressor tasks. Here is how he initially described the difference in his sensations between the two:

> …I was more focused on the technique. Like before, in the first [cold-pressor task], there was a part whenever you hope, it, you can't feel your hand. But that's because it's numb. So it doesn't feel like your hand, but you still feel it. And it feels strange. But at this point, whenever I was doing my meditation, whenever it got to the numbing part of the hand, you know there was no feeling of the actual hand. You know, being, even being there. And then after that, as I was kind of telling you, there was no feeling of being in the actual room. So I kind of got into my sensations within the body enough to basically have an out of body inside the body experience.

S11 would go on to describe this as a "transcendental state" wherein he lost all awareness of where he was and what tasks he was engaged in. This was part of a cycle that was repeated three or four times wherein he would engage in the core body scanning technique of Vipassana and would begin to feel pleasant subtle sensations in the parts of the body his attention was passing through. This would morph into a full-body experience of those sensations which would completely distract from any awareness of what was happening in his hand. Eventually this full-body awareness would shift into the transcendental state described above in which he would feel no sensations. S11 described this as a "deep, subtle mind state" and compared it to "a deep sleep state."

S11: You're not asleep, but it's in that void area of, like, deep subtle mind type of feeling.

Tim: But you're still feeling sensations, physical sensations?

S11: No.

Tim: What sensations are you feeling?

S11: Not really any at that point…Well, I guess… a state of serene peace. Maybe blissfulness at that point…

Tim: …And then, at some point, when you're in that state, you start to experience something that pulls you out of it?

S11: Yeah.

Tim: Explain that.

S11: …I guess just kind of the notion of unconsciousness, you know, getting, getting to, getting to unconsciousness and your own body wakes you up…So your body doesn't let you sink all the way into it. And if it does sink to a certain threshold, then there's a, there's an, there's an alertness, I guess, that kind of brings you back to, you know, where you are.

After regaining awareness of his surroundings, S11 would immediately feel the cold in his hand and would shift his attention away from it and back to the body scan he'd been engaged in. This is the cycle that repeated several times during CPT II.

In trying to understand his description of his experience, and in trying to make sense of how *he* understood it, I focused on two key details that call into question whether this is an example of what I hypothesized would happen for Vipassana meditators. First, there are signs that the body scanning technique is actually functioning as a highly effective distraction method. S11 focused on the subtle sensations occurring in different parts of his body and no longer felt the sensations in his hand, though it is difficult to know what level of awareness of the specific sensations in his hand might

have existed during the moments of "full-body" awareness. Second, the shift into the transcendental state that S11 describes might represent a hypnogogic state, a state of consciousness that is often described as midway between wakefulness and sleep. This state has been linked to meditation and is the focus of some meditative techniques (Thompson, 2015). A closer examination of this possibility is beyond the scope of this analysis and is unnecessary. Whatever the nature of S11's experience of a "deep sleep state" it does not correspond to the experience of subtle sensations. None of this is meant to dismiss the experience of S11 or to characterize it in any other way than the profoundly positive way that he did. But there are reasons to suspect that the sensations of cold in his hand were not being transformed or replaced by subtle sensations as I had hypothesized.

But this process does seem to have happened for S15. I will quote an exchange from our interview in which I attempted to recapitulate the descriptions of his sensational experience, one of the core techniques of micro-phenomenological interviewing (as previously described). S15 began a description of his sensations during CPT II by referencing his experiences in Zen retreats when the pain arising from immobility would flare up and would need to be managed:

> S15: And so, the teaching is much more, like, you know, notice the arising of the wish to move. Check that out. Be present with the discomfort. And there's kind of a nice place where there's the breath, I have awareness of breath, as an anchor. And there's a nice sensation of, that's something I'm familiar with, where the discomfort sort of transitions from being overt pain to really just being sensation.
>
> Tim: Describe that sensation.

S15: Light. Energy. It was neutral. I wasn't really, I'm not trying to sound like a great meditator, just you know, it's hard to realize. Like, it's almost like a dial. Like, if you wanted to teach somebody what meditation is, like, it's the sweet spot. It [the cold-pressor task] was uncomfortable enough that if I did start my mind wandering, it would start feeling a lot more uncomfortable. And when I brought my attention back to the sensation and the hand and the breath, it was quite manageable.

Tim: Okay, so I want to dig into this just a little bit more. You were saying, I guess I haven't asked you this, but you were presumably having the same stinging sensations you were having before [during CPT I]?

S15: Yeah.

Tim: And then, because you're meditating now, when your focus is on your hand, and you focus in on those sensations, and you're able to lock into your meditative practice, there's some sort of transformation of those actual sensations you're feeling?

S15: Yeah, absolutely.

Tim: Can you describe that a little bit more?

S15: …Yeah, it's a transition from the mind chattering, saying, this is uncomfortable. I hate this. I would like to end this, to the mind just being quiet, and not judging the experience or evaluating it. And it is just a sensation…Yeah, I mean the words that I would use to describe it are light and space.

Tim: So, I'm hearing you describe a transition of the actual sensations themselves rather than a reevaluation of the sensations. Is that right?

S15: Yeah, I would say that's right.

Tim: They go from a sort of stinging sensation, you accept the sensations for what they are and then, in the process, you see a transformation to where you're feeling more light, more energetic sensation?

S15: Yeah.

The terms S15 uses to describe his experience of these emergent sensations—light, energy, space—are strongly reminiscent of the terms Goenka-style Vipassana meditators typically use to describe subtle sensations. It is likely that there are significant overlaps between his experiences and the subtle sensation experience I hypothesized would occur for the Vipassana practitioners. And the results are what I predicted, namely that the subject's pain tolerance would increase (S15 did not last the full five minutes for CPT I but did for CPT II) and the quality of his experience would be transformed. That said, there is really no way of ascertaining how closely his experience of painful sensations transforming into sensations of "light" and "energy" corresponds with the subtle sensation experience in Goenka-style Vipassana without more extensive research into that phenomenon.

DISCUSSION

The primary objective of this study was to compare the responses to experimentally-induced pain of two groups of meditators of various traditions and a group of non-meditators. I hypothesized that the meditators would show substantial increases in pain tolerance post-baseline compared to the non-meditators. This did not prove to be the case. Pain tolerance increased from the first cold-pressor task to the second for a majority of subjects, but meditators as a whole did not show greater

increases than non-meditators. Furthermore, my prediction that this increase in pain tolerance would derive, in part, from substantial changes in the neurophysiological response to pain may not have borne out. Meditators and non-meditators both showed very little change in measurement of galvanic skin response, which strongly indicates that the initial, brain-stem centered, autonomic response to the painful stimuli was not different in the meditators.

Meditators and non-meditators also did not differ substantially in measurement of pNN50—a correlate of high-frequency heart rate variability (HRV)—which strongly indicates that increased activation of the parasympathetic nervous system was not substantially different between groups, though this is tempered somewhat by the substantial difference in measurement of sympathovagal balance (SVB). The fact that meditators showed a significant increase in this measure of HRV points to some neurophysiological responses to the noxious stimulus among the meditators that did not occur among the non-meditators. Several conclusions can be drawn from this. The first is that measures of high-frequency HRV may not be sufficient in themselves to capture overall fluctuations in nervous system function. HRV studies often focus primarily on measures of high-frequency changes, or time domain measures that correlate to them, because those changes are mediated exclusively by vagal nerve activity and therefore provide a pure measure of parasympathetic activation (Malik, 1996). In contrast, low-frequency changes are mediated by a complex interaction of parasympathetic, sympathetic, and baroflex activities which cannot be disentangled through HRV readings alone. This is why the use of SVB (the ratio of low frequency to high frequency HRV

readings) has been questioned by some researchers, especially those focused on detailed analyses of cardiac function and its relation to nervous system activity (Eckberg, 1997).

However, my use of SVB in conjunction with pNN50 reveals the potential inadequacy of relying solely on measures of high-frequency variability while also highlighting the need for measures like EEG to fully account for any fluctuations in low-frequency readings. In short, the readings of these two measures in conjunction point to potentially significant neurophysiological changes in the meditators, but not much can be established beyond this because of complexity surrounding changes in low-frequency HRV. This may be one reason that meditation researchers have moved on from reliance on HRV as a measure of nervous system function (Goleman & Davidson, 2017). Though I was aware of the limitations of HRV indices, I did not foresee my study providing such a perfect demonstration of the need for more precise measures; it is one of the chief lessons that I have learned from conducting it.

Notwithstanding their inadequacies to provide a clearer picture of changes in nervous system function among the meditators, these HRV indices do point to some change. And this change coincides with significant decreases in measures of pain rating and pain distress. These findings are in line with research that has found that meditation is a powerful tool in facilitating cognitive reframing in response to pain and various psychopathologies (Gard et al., 2012; Tang et al., 2015; Zeidan et al., 2011). Differences between meditators and non-meditators in my study are seen in both Likert scales and are confirmed in the more detailed descriptions of subjects' experiences seen in the phenomenological interviews. In short, the multiple self-report measures of pain intensity and accompanying distress clearly show that meditation has a positive impact on the

response of subjects to experimentally-induced pain. And this impact may contain a direct neurophysiological component, as either partial cause or partial effect, that is measured by SVB. But what accounts for this impact? Here we must more fully consider the reports of several meditators that point to the expectation that their various techniques would provide some relief or a way of better handling the painful stimuli. What this suggests is that we cannot rule out meditation functioning in a way similar to that of a placebo. As indicated by Solomon & Kucyi (2011):

> There has been considerable debate as to whether the benefits of particular psychotherapeutic interventions result from cognitive factors specific to those therapies or to factors, such as expectation of efficacy, that are characteristic of all effective treatment. (p. 12706)

Solomon & Kucyi go on to assert that this "expectation of efficacy" applies to mindfulness as a clinical treatment and that "such beliefs may result in unconscious biases toward self-report consistent with these stated benefits (e.g., reductions in unpleasantness ratings)" (p. 12706). This expectation of efficacy is precisely what was seen in several of the meditators in my study and calls into question whether it was the meditative techniques themselves that impacted the decrease in ratings of pain intensity and distress or if these changes would better be attributed to the demonstrated positive impact that expectation can exert.

Studies of the placebo response to experimentally-induced pain have also demonstrated complex neurophysiological changes associated with conditioned analgesia, a type of "placebo-induced modulation of pain" (Lui et al., 2010, p. 822; Watson et al., 2009). Details of these changes are beyond the scope of this thesis, but it is

reasonable to speculate that fluctuations seen in meditators' SVB measures in my study could potentially correspond to changes that were measured in these placebo studies employing fMRI. However, another possibility is that there are neural responses to pain that are specific to meditative practice and distinct from placebo. This is the conclusion drawn from a study by Zeidan et al. (2015) when comparing fMRI results of groups representing four conditions: mindfulness meditation, placebo, a sham mindfulness meditation, and a control group. Zeidan et al. found that each active condition resulted in effective modulation of the pain response but that mindfulness meditators showed the most substantial effects and functional imaging showed distinct markers for the mindfulness group. Again, details of their results are outside the present scope of this thesis. But what they point to is the possibility that SVB readings in the current study might indicate neurophysiological changes more directly attributable to meditative practice than any type of conditioned analgesia. In the end, it is simply not possible to know which interpretation of the data is more appropriate because of limitations in the neurophysiological indices that I used.

A secondary hypothesis of my study was that Vipassana meditators would experience a shift in the quality of painful sensations occurring in their submerged hands—a change from the typical sensations of cold to sensations that are often described as pleasant, energetic vibrations—and that these sensations would increase their pain tolerance, decreasing both ratings of pain intensity and distress. My study was far too underpowered to fully explore this possibility, but it is illustrative to look again at the experience of S15 and what that might tell us about this phenomenon and about the efficacy of meditative practice as a method of pain management.

As described above, S15 experienced a change in sensations in his submerged hand from those typical of intense cold to sensations that he described as “light”, “energy”, and “space.” This facilitated precisely the increase in pain tolerance that I had predicted, as well as a decrease in distress. But two things are crucial to note. The first is that S15 was, far and away, the most experienced meditator of any of the subjects and had spent significantly more time in silent retreat than any other. It is time in silent retreat especially that has been found to correlate with significant neurophysiological changes in meditators in studies of Tibetan monks (Goleman & Davidson, 2017; Davidson & Kaszniak, 2015). So, though it was surprising to me that it was a Zen meditator who experienced the phenomenon that I predicted would occur primarily in those who practice Vipassana, it was not surprising that the lone meditator to demonstrate this phenomenon was also the most experienced. However, it must also be noted that S15 did not display any of the neurophysiological changes that I assumed would accompany that experience. Neither his GSR nor pNN50 measures changed significantly between the two cold-pressor tasks, which indicates that his experience was likely not related to activation of the parasympathetic nervous system. Whatever neurophysiological changes occurred in S15 that correlate to his experience of “subtle sensations” were not readily apparent in the indices I used.

But the kind of neurophysiological changes that I predicted would occur for the subjects in the meditation groups did occur for S7, and her experience is also instructive. S7 utilized a collection of meditative techniques from visualization to deep breathing and humming. These techniques had been honed over the years as a direct response to the chronic pain that she’d been forced to deal with her entire adult life. Like S15, she

showed significant increase in pain tolerance in the second cold-pressor task, going the entire five-minutes after lasting substantially less time during the first. Unlike S15 and every other subject, however, she showed a ten-fold increase in parasympathetic activation as measured by pNN50. The techniques that she had fine-tuned seemed especially well-suited for dealing with both experimentally-induced pain and the chronic pain with which she was familiar. And this fine-tuning took place in the absence of any time spent in silent meditation retreat, as well as with minimal instruction. When looking at these two meditators, I am inclined to conclude that traditional meditation practice may not be the most effective or efficient method of dealing with pain. It can certainly help and at the extremes of meditative experience, practitioners have displayed profound abilities of endurance. But when we are looking for techniques that might help chronic pain sufferers manage their various conditions, it may prove more advantageous to focus on specific breathing and distraction techniques or on programs like Mindfulness-Based Stress Reduction (MBSR) and its derivative programs that have specifically tailored MBSR to pain management.

Limitations and Future Directions

As noted, my study was severely underpowered, given that I was unable to recruit sufficient numbers of Vipassana meditators needed to fully explore how practitioners of Vipassana compare with meditators using other techniques or practicing other traditions. Any future study of this kind would likely need to be conducted in larger urban areas relatively close to one of the many permanent Vipassana centers located throughout the United States and the rest of the world. Recruitment was further hampered by the unwillingness of authorities within the North American administrative region of the

Vipassana Research Institute to allow access to their member databases or contact with their students through list servers that they maintain. I was further prohibited to post advertisements for my research at the North American centers that I had access to. Such restrictions do not appear to be worldwide, and significant studies of Vipassana have been done in India by researchers who have been allowed to directly recruit from practitioners at the centers there (Kakumanu et al., 2018). As I move forward with future studies, I will explore the possibility of collaborating with these researchers which, along with the practical benefits of being able to more easily recruit Vipassana meditators, will also allow for a broader set of cultural perspectives to be brought to bear on any of the phenomena being studied.

Another limitation arose from recruitment difficulties that I predicted during the design phase. Knowing that it can be a challenge to find and recruit experienced meditators, I decided to compare three groups—a meditation-naïve control group, a group of Vipassana meditators, and a hybrid group of meditators who practice other traditions and/or techniques. The composition of this last group was a concession to the difficulties other researchers and I have experienced recruiting intermediate to experienced meditators. But the results of my study highlight the need to compare traditions more directly. Future studies of Vipassana and its attendant phenomena would benefit from a direct comparison of Vipassana practitioners with comparably experienced practitioners of traditions like Zen or Dzogchen. It might still be beneficial to compare these groups with a heterogeneous group of practitioners of various mindfulness techniques and with a meditation-naïve control group, but *multiple* traditions, practiced in their fullness, need to be part of future comparisons. This need is illustrated by the

somatosensory experience of S15 and its similarities to phenomenal reports of Vipassana meditators. Exploring areas of overlap and distinction within these traditions at both the neurophysiological and phenomenological levels will likely yield greater understanding of meditative practice in general and what techniques are most useful as clinical interventions in particular.

A study design that compares multiple traditions might also help alleviate aspects of the expectation problem described earlier. Other methodological efforts to address it have typically centered on the inclusion of an active control group, like the sham meditation group in the Zeidan et al. (2015) study. But these experimental designs rely on the ability to randomize subjects and train them in specific meditative techniques and "sham" equivalents that function as placebo (Davidson & Kaszniak, 2015; Tang et al., 2015). It is difficult to apply such a design to a quasi-experimental, traditions-based approach to meditation research, as those subjects cannot be randomly grouped and the practitioners of the meditative traditions are likely to experience some degree of positive expectation no matter what efforts are expended to control it. The difficulty is such that it has compelled some proposed solutions that are problematic. Davidson and Kaszniak (2015) have suggested paying control group subjects more than subjects in the active groups in an effort to increase their performance on various comparative tasks, making it more comparable to the performance of meditation groups. How this would be quantified is an open question, and the idea seems dubious at best. But a direct comparison of different traditions avoids some of these problems, as the practitioners of each group would likely experience comparable levels of expectation. Furthermore, if neuroimaging methods like EEG or fMRI are used, it may be easier to distinguish neurophysiological

fluctuations that are caused by specific meditative practice from those caused by expectation.

Whatever direction future studies take, my study highlights the need to include more sophisticated measures of neurophysiological functioning such as EEG or fMRI. Indices like heart rate variability might still be useful in those studies as rough measures of nervous system function. But to understand more precisely what differentiates the neural functioning of different groups, more precise measures of neural activity are necessary.

On a more positive note, my study highlights the utility of, and potential need for, including qualitative measures in future studies of meditation. Understanding the lived experience of meditators is crucial to a proper evaluation of their practices and how those practices are related. In my study, without the element of Interpretive Phenomenological Analysis, I would not have had a clear sense of how the expectations of the meditators might be influencing results, nor would I have been able to see the similarities between a high-level Zen practitioner and the Vipassana meditators that I was specifically interested in studying. Certain phenomena like the self-evaluation mechanisms demonstrated by a majority of subjects would likewise have remained hidden, and I would have had an incomplete picture of the various practices each meditator engaged in as well as the details of how each one oriented to the pain of the cold-pressor tasks. Meditation, at its heart, is a phenomenological practice, and methods that explore this central quality of the discipline are necessary to truly understand it and how it might best be utilized in pain control and management.

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