ABSTRACT

Music and Suggestion: An Exploration of the Effects and Mechanisms of an Arts-Based Mind-Body Intervention for Pain

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Pain is a growing public healthcare challenge that affects millions each year. Despite recent scientific advances in the diagnosis and treatment of pain, pain is often undertreated. Undertreated pain is associated with higher rates of developing comorbid chronic diseases, mental health issues, chronic pain, and disability. There is growing scientific support for the use of arts-based mind-body interventions, such as music and suggestions, in multidisciplinary pain management. However, it is largely unknown how, and for whom, these treatments may be most beneficial. It has been proposed that music and suggestions may be an effective adjunct in pain management through multiple psychological mechanisms, including relaxation, emotion, distraction, self-efficacy, expectation and absorption. The purpose of this study is to compare the effects of music and suggestion to music alone on laboratory pain, and to explore possible mechanisms for their action. Sixty-six college-aged females were enrolled in a randomized controlled trial comparing music listening combine with positive suggestions to music listening and a no-treatment control on cold pressor pain. Participants completed a battery of psychological

and physiological measures to provide further insight into the possible variables related to the observed effects of music and suggestion on pain. The results of this study indicate that music with or without suggestion may be beneficial in improving certain dimensions of pain. A discussion of the implications and limitations of these findings follows.

Music and Suggestion: An Exploration of the Effects of an Arts-Based Mind-Body Intervention for Pain

by

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A Dissertation

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# DEDICATION

To the love of my life, Brooks Johnson. Your strong faith, unconditional love, unwavering devotion, strength in my weakness, assuring kindness, and wicked sense of humor carry me through. Thank you for perspective.

# CHAPTER ONE

## Introduction

> *By any reasonable code, freedom from pain should be a basic human right, limited only by our knowledge to achieve it.*
>
> Ronald Melzack

Pain management is a primary concern in health care (Fishman, 2007), and one of most common reasons people seek medical care (Gaskin & Richard, 2011). Pain accounts for approximately 80% of physician visits and 40% of emergency department admissions each year in the United States (Fishman, 2007; Gaskin & Richard, 2011; Gatchel, 2004; Pletcher, Kertesz, Kohn, & Gonzales, 2008). It is estimated that over 126 million U.S. adults experience frequent pain (Nahin, 2015).

Despite great advances in pain management, many patients still report undertreated pain. For example, 80% of surgical patients report inadequate pain management postoperatively, of which 88% report moderate to extreme pain (Gan, 2017; Institute of Medicine, 2011). Untreated acute pain increases the risks for medical complications, slow or incomplete recovery, disability, and chronic pain (Gan, 2017; Grichnik & Ferrante, 1991). In addition, under-managed pain increases patients' risks for experiencing psychological comorbidities, poor sleep, fatigue, and social isolation (Ashburn & Staats, 1999; Gureje, Von, Simon, & Gater, 1998; King & Fraser, 2013; Lohman, Schleifer, & Amon, 2010).

Pain is costly: personally, monetarily, and socially. The financial costs of pain are estimated to range between $560 and $635 billion dollars annually in the United States, a

cost that exceeds that of cancer and diabetes combined (Gaskin & Richard, 2011). In addition, people experiencing ongoing, undertreated pain report greater financial hardships, increased levels of distress, lower quality of life, and strained interpersonal relationships (Gatchel, 2004; Jensen & Turk, 2014; Silver, 2004).

Pain is difficult to diagnose and treat due to its complex, multidimensional, and subjective nature. It is now recognized that pharmacological pain management is often unsatisfactory for patients with acute and chronic pain (Institute of Medicine, 2011), and that multidisciplinary approaches that target psychological and social aspects of pain may improve pain management and overall patient care (Fashler et al., 2016; Institute of Medicine, 2011; Morone & Greco, 2007). There is a growing interest in the use of arts-based mind-body interventions, such as music, for pain (Cheever et al., 2018; Institute of Medicine, 2011).

Research indicates that music may be beneficial in reducing pain and its associated symptoms (Morone & Greco, 2007; Jensen & Turk, 2014). For example, music listening has been shown to reduce postoperative and non-malignant chronic pain (Mercadie, Mick, Guetin, & Bigand, 2015; Bernatzky, Strickner, Presch, Wendtner, & Kullich, 2012; Garza-Villarreal et al., 2014; Finlay & Anil, 2016; Nilsson, 2008), and has been recommended as an adjunctive treatment for cancer pain by the National Cancer Institute (National Cancer Institute, 2014). However, these benefits are not universal and evidence for its utility in the medical setting is inconsistent. Inconsistencies may be due to a lack of standardization in the dose and delivery of the intervention. It is possible that music delivered with or without suggestions (e.g. explicit or implicit) may act on different mechanisms resulting in varied outcomes.

It is largely unknown how music may exert its effects on pain. It is possible that that music listening may be effective by providing a distraction (Good et al, 1999; Finaly & Anil, 2016; Mitchell & MacDonald, 2006; Willis, 1985), or by producing a relaxation response that reduces anxiety and influences mood in a positive way (Dileo, Bradt, Crocke, & Magill, 2008; Koelsch, 2005). It is also possible that music listening is more effective when it is combined with positive suggestions for relaxation and pain relief (Melzack, Weisz, & Sprague, 1963; Nilsson, Rawal, Uneståhl, Zetterberg, & Unosson, 2001; Nilsson, Rawal, Enqvist, & Unosson, 2003). It is possible that when music listening is preceded by suggestions (e.g. for comfort, relaxation, absorption, and pain reduction), that the listener is better able to focus on the music and the music becomes a more powerful distractor. It is also possible that once the listener has focused their attention on the music that the music then functions as a type of hypnotic induction whereby the listener is able to use previous suggestions in a type of self-hypnosis.

In a preliminary feasibility trial, Johnson and colleagues (2017) found evidence for the positive effects of a combined music and suggestion intervention on pain and its associated symptoms (e.g. anxiety, negative affect) among seriously ill patients. The purpose of this study is to further explore the effects and potential mechanisms of music combined with suggestion on pain.

The current study was designed to satisfy four primary aims:

*Specific Aims*

*Aim 1*: Determine effect sizes of music plus suggestion for the primary outcome of pain (e.g. threshold, tolerance, intensity and unpleasantness).

*Aim 2*: Compare the effects of music plus suggestion to music alone and no treatment control on experimental pain.

*Aim 3*: Explore potential mechanisms of M+S (e.g. relaxation, distraction, absorption, anxiety, mood, perceived control, expectancy, and hypnotizability).

*Aim 4*: Examine the effect of music and suggestion on heart rate and blood pressure.

It is hypothesized that music combined with suggestions (M + S) will have a detectable, positive impact on experimental pain indicators (i.e. threshold, tolerance, intensity, unpleasantness). It is hypothesized that M+S will reduce pain over and above music listening without suggestions (M), and that both interventions will be more effective than a silence control (NT). It is further hypothesized that anxiety, relaxation, distraction, absorption, perceived control, mood, expectancy, and hypnotizability will explain portions of the observed effects of M + S on pain. It is also hypothesized that participants will exhibit less cardiovascular reactivity in the M + S condition than participants in the M or NT conditions, but that these changes may not mirror self-reported pain.

The results of this study will build upon current scientific knowledge and provide a basis for developing a conceptual model of music and suggestion for pain. Findings from this line of research will be used to generate new hypotheses on the use of music and suggestion as adjuncts to pain management and provide support to the existing literature.

# CHAPTER TWO

# Literature Review

## *Defining Pain*

Pain is universal. Pain, in its most adaptive form, serves as a protective warning system. In its most maladaptive form, it can be detrimental, a destructive force touching every aspect of a person's life. Pain is a complex and subjective experience that is comprised of biological, psychological, and social factors (Gatchel, 2004; Melzack & Casey, 1968; Price, 1999). Pain has been defined as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (International Association for the Study of Pain (IASP), 1994, p.210). Pain is usually classified according to duration (e.g. acute or chronic) or underlying pathophysiology (e.g. malignant, non-malignant, neuropathic, or inflammatory) (IASP, 1994). These classifications are not mutually exclusive, (e.g. acute-on-chronic non-malignant pain), which may add further complexity to its successful treatment (IASP, 1994).

### *Pain Classifications*

Pain may be classified as acute or chronic, based on duration. Acute pain is defined as "pain of recent onset and probable limited duration" (Koneti & Jones, 2013, p. 84), and is the body's normal response to injury or tissue damage. Acute pain usually occurs as the result of a specific disease or injury, or surgical procedure, serves as a

biological warning system, and is time limited (Grichnik & Ferrante, 1991; Lipman, 2005).

It is possible for severe or prolonged acute pain to develop into chronic pain via discrete pathophysiological processes involving multiple pain systems (Kehlet, Jensen, & Woolf, 2006; Voscopoloulos & Lema, 2010). Chronic pain by definition, is pain lasting past the normal healing time, usually defined as three to six months (Bonica, 1953; International Association for the Study of Pain, 1994). Chronic pain may be the result of an injury (e.g. traumatic brain injury, amputation), or an ongoing disease process (e.g. arthritis, cancer, multiple sclerosis), or the primary symptom of an ongoing chronic condition (e.g. diabetic neuropathy, complex regional pain syndrome) (Johannes, Le, Zhou, Johnston, & Dworkin, 2010; Institute of Medicine, 2011). Unlike acute pain, chronic pain may persist or worsen without evidence of tissue damage or biological cause (Turk, Wilson, & Cahana, 2011).

*Psychosocial Treatments for Pain*

The study of pain and its treatment dates back to antiquity (Dallenbach, 1939). Early models of pain (e.g. Specificity Theory, Pattern Response) focused primarily on peripheral processes (e.g. direct responses to noxious stimuli). While useful, these theories were limited by their reductionist approaches. In the early 1960's a paradigm shift in pain research occurred with the publication of Melzack and Wall's Gate Control Theory (1965). The Gate Control Theory was novel in that it recognized the complexity of pain and its perception and replaced the long-held belief of a one-to-one relationship between stimulus intensity and pain perception (Melzack & Wall, 1965). The Gate Control Theory also replaced previous theories of "straight-through" pain transmission

(e.g., skin receptors to a "pain center in the brain"), with a more robust conceptualization. According to the Gate Control Theory, pain transmission is controlled by central nervous system mechanisms located in the dorsal horn of the spinal cord that inhibit or facilitate pain signal transmission from body to brain (Melzack & Wall, 1965).

The Gate Control Theory triggered a rapid advance in the science of pain and the identification of potential neurological pathways by which pain is processed. However, the Gate Control Theory was not entirely adequate as it was unable to account for observations of paraplegic pain and chronic pain (Melzack, 2001). Thus, a new theory emerged to address these limitations. The Neuromatrix Theory of pain (Melzack, 2001) postulates that a widespread complex of interconnected neurons (e.g. neuromatrix), produces cyclical processing and synthesis of nerve impulses that results in a pattern (i.e., neurosignature *of body-self*). This neuromatrix is itself produced by genetic and sensory experiences and produces a neurosignature, that may be triggered by input (e.g. noxious stimulus), which ultimately results in awareness and action.

The Neuromatrix Theory fits within the larger biopsychosocial model, one of the most widely accepted models of pain (Institute of Medicine, 2011). The biopsychosocial model (Engel, 1977) was created to describe the interrelated biological, psychological, and social factors on health and disease (Engel, 1977). It has recently been adopted by pain theorists and continues to be developed (Day, Thorn, & Burns, 2012). According to the biopsychosocial model, pain is a multidimensional experience that consists of multiple integrated processes, including biological, psychological, and social (Gatchel et al, 2007; Jensen & Turk, 2014). It acknowledges the cognitive and affective processes of pain (Garland, 2012), and provides a framework for understanding how psychosocial

interventions may improve pain (*Figure 2.1*) (Cohen, Quintner, & Buchanan, 2013; Day et al., 2012; Gatchel, 2004; Gatchel et al., 2007; Institute of Medicine, 2011). Acceptance of the biopsychosocial model for pain has led to the development of pain interventions that extend beyond traditional biomedical approaches (Okifuji & Turk, 2015).

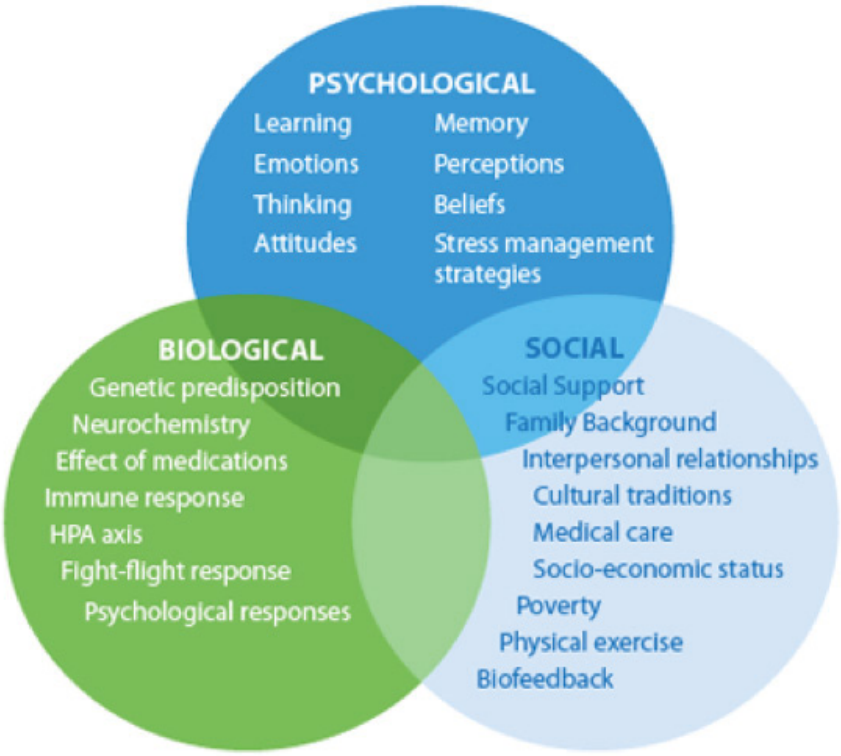


*Figure 2.1*. A biopsychosocial model for pain.

*Specific Psychological Models of Pain*

A growing understanding of the cognitive, affective, and social components of pain have led to the development and implementation of psychosocial interventions for pain treatment. Psychological theories have been developed that attempt to explain how these interventions may produce their effects on pain. These include: 1) operant

conditioning, 2) peripheral physiological models, 3) cognitive and coping models, and 4) central neurophysiological models (Jensen & Turk, 2014).

*Operant conditioning.* Early psychological pain management was based in the operant model of behavior (Jensen & Turk, 2014). According to this theory, pain behaviors could be the result of actual nociceptive stimulus or a conditioned response (Fordyce, 1978). According to this theory, pain behaviors function as a conditioned response due to reinforcing events, such as sympathy or affection, and eventually become maladaptive behavior patterns (Fordyce, 1978). This idea is further extended in cases of observational learning, whereby people observe the response others get for particular behaviors (e.g. in hospital or pain treatment facility) and adopt those behaviors themselves (Goubert, Vlaeyen, Crombez, & Craig, 2011). According to the operant model, a key aspect of treating ongoing pain is "having patients …focus attention away from the pain experience…" (Jensen & Turk, 2014, p. 107). Patients are then reinforced for focusing attention on improvements in both psychological and physical functioning, instead of receiving reinforcement for pain behaviors. In line with this theory, psychosocial interventions that require patients to focus their attention on positive experiences, and provide a distraction from pain, could be effective in reducing pain and promoting more adaptive behaviors that lead to improved functioning.

*Peripheral physiological.* Peripheral physiological models posit that pain reduction may occur as an individual is able to regain feelings of physiological control over processes that contribute to pain and learn relaxation techniques to reduce peripheral contributions to pain (Jensen & Turk, 2014). According to this theory, decreases in

muscle tension results in decreased pain. Much like biomedical models, the emphasis was placed on peripheral processes, with less focus on the contributions of central processing to the pain experience (Jensen & Turk, 2014). Recent studies of the effects of relaxation support its use in pain control (Ostelo et al., 2005). However, some of the benefits of relaxation training techniques for pain may be due to increased feelings of self-efficacy and changes in pain beliefs that lead to reduced stress and improved outcomes (Holroyd et al., 1984; Nouwen & Solinger, 1979). Therefore interventions that target both peripheral processes (e.g. muscle tension) and central processes (e.g. self-efficacy, pain cognitions) could be effective in reducing pain and its unpleasantness.

*Cognitive coping models.* Cognitive coping models focus on the beliefs, attributions, and expectations people hold when considering treatment options for pain. Psychologists treating pain began developing interventions based on this model in the 1980's. It has since come into wide use with the development of cognitive behavioral therapy (CBT) (Turk, Meichenbaum, & Genest, 1983). Pain interventions based on this model consider cognitive processes, beliefs, attributions, and motivations to be salient treatment targets for reducing pain (Jensen & Turk, 2014). As a person is able to regain control over emotions and cognitions and change maladaptive coping patterns, self-management improves leading to reduced pain and improved functioning (Eccleston, Williams, & Morley, 2009; Morley, 2011; Ostelo et al., 2005; Palermo, Eccleston, Lewandowski, Williams, & Morely, 2010). According to this model, treatments that incorporate self-care strategies designed to improve mood, reduce stress, anxiety, and depression, and facilitate adaptive coping strategies may be beneficial in managing

chronic pain (Berman, Iris, Bode, & Drengenberg, 2009; Velasco Furlong, Zautra, Peñacoba Puente, López-López, & BarjolaValero, 2010).

*Central neurophysiological models.* As briefly stated before, central neurophysiological models of pain began with Melzack and Wall's (1965) Gate Control Theory which shifted the perspective of pain from peripheral processes to centrally modulated processes. According to Melzack and Wall (1965) central processes could modulate the experience of pain by 'opening or closing the gate' that would either allow or inhibit central pain processing and control how much pain was experienced. It was recognized that attention, affect, and experience could all influence these central processes (Jensen & Turk, 2014). Rapid technological advances led to the development of new neurophysiological theories (e.g., Neuromatrix Theory), which draw attention to the multiple cortical systems involved in the pain experience (e.g. prefrontal cortex, anterior cingulated, insula), and how the interruption of pain responses in these systems may provide relief (Apakarian, Baliki, & Geha, 2009; Jensen & Turk, 2014). For example, interventions that are effective in promoting positive affect, reducing anxiety, and fostering positive coping could alter pain perception through central processes (e.g. anterior cingulate cortex, insula).

As a whole, the biopsychosocial model, psychological models, and neurophysiological models all point to the potential benefits of psychosocial interventions for pain. It is reasonable to conclude that psychological interventions that increase self-efficacy, provide a distraction, increase positive expectations, foster positive emotions and improve mood, reduce anxiety and increase relaxation may reduce pain and its impact on psychological and physical functioning (Jensen & Turk, 2014).

*Experimental Pain Research*

Experimental pain methods are valuable, low cost tools for determining the analgesic properties of an intervention in a controlled environment, serve as an informative prerequisite to clinical studies (Gracely, 1991; Rainville, Feine, Bushnell, & Duncan, 1992; Walsh, Schoenfeld, Ramamurthy, & Hoffman, 1989), and have been historically utilized in the development of novel pain treatments (Marchand, Bushnell, Molina-Negro, Martinez, & Duncan, 1991). While it is recognized that experimental pain paradigms do not replicate the complexities of clinical pain (e.g. fear, anxiety, illness burden, sleep disturbances, depression), experimental pain trials have been shown to provide relevant information that can inform treatments of clinical pain (D'Antono, Ditto, Rios, & Moskowitz, 1999; Edwards, Doleys, Fillingim, & Lowery, 2001; Fillingim, Maxiner, Kincaid, Sigurdsson, & Harris, 1996; Hilgard, 1978; Keats, Beecher, & Mosteller, 1959; Edwards, Sarlani, Wesselmann, & Fillingim, 2005). Experimental pain trials allow for precise pre- and post-treatment pain measurement with standardized stimuli and are considered reliable indicators of pain responses (Edens & Gil, 1995). Therefore, the use of experimental pain trials can inform the larger science of pain about potential treatment targets and possible mechanisms of action.

Cold pressor pain is thought to mimic characteristics of clinical pain more than other experimental pain stimuli due to its unpleasantness (Rainville et al., 1992), and has been commonly used to assess the analgesic effects of other psychosocial interventions (Ashton, Ebeneezer, Golding, & Thompson, 1984; Freeman, Barabasz, Barabasz, & Warner, 2000; Hodes, Howland, Lightfoot, & Cleeland, 1990; Weisenberg, Scharzwald, & Tepper, 1996). In addition, the use of the cold pressor trial mimics the suprathreshold

pain response that is more characteristic of clinical pain (Edwards et al., 2005), and has been shown to be a reliable, safe and valid measure (Edens & Gil, 1995).

## *Music and Suggestion for Pain*

Previous research indicates that music and suggestion may be effective for pain relief (Guetin et al., 2012; Roy, Lebuis, Hugueville, Peretz, & Rainville, 2012; Korhan et al., 2014). However, few studies have assessed their combined effects or the mechanisms by which music and suggestion may reduce pain.

### *Music*

For the purpose of this study, music is conceptualized as "listening to music." Listening to music for pain reduction is often referred to as music analgesia or music medicine (Garcia & Hand, 2016). Music listening may be classified as active (listening to music is the primary activity), or passive listening (listening while engaged in another primary activity) (DeSantis, 2015). Music listening is distinct from music therapy in that it does not involve multiple music modalities or require the presence of a trained music therapist.

### *Music for Pain*

Previous research indicates music listening may be an effective adjunct for acute and chronic pain relief (Cepeda, Carr, Lau, & Alvarez, 2006; Hole, Hirsch, Ball, & Meads, 2015; Nilsson, 2008). In a recent meta-analysis, Hole and colleagues (2015) found music reduced postoperative pain on average 23%, a clinically meaningful effect (Dworkin et al., 2009). In addition, music has been demonstrated to reduce anxiety and analgesic consumption and improve patient satisfaction following surgery (Engwall &

Dupplis, 2009; Hole et al., 2015; Nilsson, 2008). In a randomized controlled trial of 311 women undergoing gynecological surgery, music improved the analgesic effects of standard postoperative pharmaceutical interventions (Good, Anderson, Stanton-Hicks, Grass, & Makii, 2002). Women who listened to music required less medication (i.e. opioids) and reported less pain than in the standard care group (Good et al., 2002). In addition, a review of 17 randomized controlled trials ($n$ = 1,937), music demonstrated positive benefits, including reduced pain, analgesic requirements and anxiety, among hospitalized patients (Cole & LoBiondo-Wood, 2014).

However, the findings are inconsistent (Cepeda et al., 2006). Studies have indicated that listening to music may be no more effective in reducing pain than listening to other types of sounds, such as environmental sounds (Mercadie et al., 2015), or standard care (Cepeda, Diaz, Hernandez, Daza, & Carr, 1998; Chen, Chen, Huang, Hsleh, & Lai, 2015; Taylor, Kuttler, Parks, & Milton, 1998). In a series of studies, researchers found self-chosen music was beneficial for anxiety reduction, but had no statistically significant effect on pain following ambulatory surgery (MacDonald et al., 2003).

It is possible that the contradictory results may be partly due to large variations in the dose, delivery, and type of music interventions employed across studies. It is also possible that patient perceptions of the intervention also influence the observed effect. For example, in a recent study investigating the effects of music listening on pain and opioid consumption in critical care patients, researchers reported that music was statistically effective for self-reported pain (e.g. NRS) on the first day of admission, but that the effect was not sustained. The researchers concluded that the diminishing effects were due to large variability in patient listening and acceptance of the intervention (Ames

et al., 2017). The patients that had continued to utilize the intervention reported higher levels of overall patient satisfaction at the end of the study (Ames et al., 2017).

Blankfield and colleagues (1995) investigated the use of taped therapeutic suggestions and taped music as adjuncts in the care of coronary artery bypass patients. Sixty-six patients were randomly assigned to listen to either suggestion or music tapes intraoperatively and postoperatively, while 29 patients listened to blank tapes intraoperatively and no tapes postoperatively. Though the differences between groups for anxiety or analgesic consumption were not significant, the majority of patients receiving either tape reported that the intervention was helpful. The 'helped' group (n=33) showed positive trends in reduced analgesic consumption. The authors noted in that many patients did not engage with the therapy, only listening to the intervention for a short period of time before discontinuing use.

Contradictory clinical findings of music for pain are replicated in the experimental pain literature. Researchers have demonstrated that music may be beneficial for pain through the use of experimental pain trials (Finlay & Anil, 2016; Garcia & Hand, 2016; Mitchell, MacDonald, & Knussen, 2008), yet the effects are not universal. For example, Garcia and Hand (2016) compared the effects of two types of music and a silence condition on cold pressor pain among 30 health participants. Participants underwent three cold pressor trials and reported on pain intensity, pain unpleasantness, and mood for each of the interventions. In addition, cardiovascular indices were measured for each trial. Results from this study indicate that relaxing music was superior to silence for reducing self-reported pain unpleasantness, $d = .49$, $p = .007$. However, there were no statistically significant differences among any of the other pain variables.

These findings indicate the pain relieving effects of music may be dimension specific. Despite these difficulties, experts agree that "listening to or making music profoundly changes the brain by modulating cognition, emotion, multisensory, and motor networks" (p. 1217), and that music may provide an effective tool in a multidisciplinary approach to pain management (Cheever et al., 2018).

*Suggestion*

Suggestion can be defined as "verbal or non-verbal messages that the receiver involuntarily accepts and follows" (Szilágyi, Kekecs, & Varga, 2017, p. 2). Verbal suggestions may be hypnotic (i.e. preceded by a hypnotic induction), or non-hypnotic (i.e. without a hypnotic induction) (Hilgard, 1978). Non-hypnotic suggestions have been referred to as therapeutic suggestions, positive suggestions, imaginative suggestions, or waking suggestions, and can be delivered without the presence of a trained hypnotherapist.

Researchers have shown that it is possible for suggestions to be effective outside of the context of hypnosis. In a study comparing the effects of suggestions (hypnotic and non-hypnotic) to placebo found both types of suggestions to be superior than control for the reduction of experimental pain (Milling et al., 2005). The results of this study indicate that suggestions may be effective despite level of hypnotizability when provided in a meaningful context (Milling, Kirsch, Allen, & Reutenauer, 2005).

Suggestion has also been shown to increase placebo analgesia in laboratory-induced pain through successful manipulation of expectancy, irrespective of an individual's suggestibility level (e.g. Sensory Suggestibility Scale (SSS) (De Pascalis, Chiaradia, & Carotenuto, 2002). In another experimental study of suggestion for pain, 36

healthy participants were randomly assigned to receive positive placebo suggestions (e.g. favorable messages about ice water immersion), negative placebo suggestions (e.g. depictions of the negative effects of ice water immersion), and control (e.g. neutral messages about ice water exposure) during a cold pressor test (Staats, Hekmat, & Staats, 1998). Participants receiving positive suggestions demonstrated a statistically significant increase (44.5 seconds) in pain tolerance compared to the neutral condition while those receiving negative suggestions demonstrated a statistically significant decrease (29.1 seconds) compared to the control condition (Staats et al., 1998).

Suggestions may be effective for pain when employed on their own or in conjunction with other therapies (Kekecs, Nagy, & Varga, 2014). For example, Bingel and colleagues (2011) tested the effects of both positive and negative suggestions on the analgesic effects of a powerful opioid (i.e. remifentanil) in healthy volunteers. Positive expectancies significantly enhanced the analgesic effects of the drug while negative treatment suggestions rendered the analgesic ineffective (Bingel et al., 2011). Suggestions have also been shown to reduce fibromyalgia pain (Derbyshire, Whalley, & Oakley, 2009), laboratory-induced pain (Milling et al., 2005), and blood loss during orthopedic surgery (Szeverényi, Csernátony, Balogh, Simon, & Varga, 2016).

In addition, suggestions may be useful in overcoming automatic responding. Researchers comparing the effects of hypnotic suggestion to non-hypnotic suggestion on the Stroop effect in highly suggestible individuals found that both types of suggestion were able to overcome automatic responding to this task (Raz, Kirsch, Pollard, & Nitkin-Kaner, 2006). The ability for suggestions to overcome automatic processes may be a useful strategy in reducing learned pain behaviors (e.g. operant conditioning).

*Music Combined With Suggestion*

There are a limited number of studies in which researchers have purposefully investigated the combined effects of music and suggestion. Findings from the few available studies are mostly positive. Melzack et al (1963) reported the combined effects of music and suggestion intervention were superior to either music or suggestion alone on cold pressor pain. Nilsson and colleagues (2001) demonstrated that surgical patients receiving intra-operative music plus suggestions required less rescue analgesics, could be mobilized earlier, and reported less fatigue upon hospital discharge compared to patients receiving music or white noise. In another study, Nilsson and colleagues (2003) found music combined with therapeutic suggestions was more effective in reducing postsurgical pain than music alone or in the standard care control group. A recent pilot study indicated music combined with suggestions have the potential to reduce self-reported pain in seriously ill patients with chronic pain (Johnson et al., 2017).

However, there is some evidence that points to an opposite conclusion. As a follow up to Melzack's (1963) study, Morosko and Simmons (1966), did not find suggestions improved the effects of music on electrical pain. It is possible this is due to the use of different types of pain or differences in suggestions.

*Mechanisms*

The mechanisms by which music and suggestion reduce pain are largely unknown. Previous research indicates the effects of music and suggestion may be largely due to the affective and cognitive dimensions of central pain processing.

*Emotion.* It has been suggested that music may be effective for pain due to its positive effects on emotional processes (Juslin & Vastfjall, 2008; Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). Listening to music is a pleasant experience for most people and has been shown to elicit positive emotional states (Dubé, & Le Bel, 2003, Sloboda & Juslin, 2001; Krumhansl, 1997). It has been proposed that music analgesia may act on emotional processes in the listener and thereby reduce pain perception (Bernatzky, Presch, Anderson, & Panksepp, 2011; Garza-Villarreal et al., 2014; Salimpoor et al., 2011). In addition, suggestion has been shown to be capable of altering emotions in studies of pain (Rainville, Bao, & Chretien, 2005). Pain theory suggests that there is a strong emotional component to pain and that negative emotions and mood can increase feelings of pain (Fernandez & Turk, 1995; Rainville et al., 2005). By evoking more positive emotions, music and suggestion may decrease the perception of pain. In support of this theory, it has been demonstrated that emotional responses to music activate the limbic region in the brain and can result in the release of endogenous opioids (e.g. dopamine) that alter pain perception (Salimpoor et al., 2011).

*Relaxation.* Other studies of music and suggestion have proposed that relaxation produced by the intervention may reduce pain. This is consistent with current peripheral and central processes pain theories that posit pain modulation occurs through both afferent and efferent pathways that respond to mental and physical relaxation (Gatchel et al., 2007; Taylor, Goehler, Galper, Innes, & Bourguignon, 2010). Music and suggestion have been demonstrated to affect heart rate (Trappe, 2009), and reduce cardiovascular responses to thermal stress (Casiglia et al., 2007).

*Anxiety.* Anxiety is associated with increased pain (Davis, Kroenke, Monahan, Kean, & Stump, 2016). Empirical investigations of psychological interventions for acute, experimental, and chronic pain note the close association between pain and anxiety (Mitchell, MacDonald, Knussen, & Serpell, 2007; Nilsson, 2008; Simons, Elman, & Borsook, 2014). Many psychological interventions are targeted to reduce anxiety to improve outcomes (Jensen & Turk, 2014; Simons et al., 2014). Music and suggestions may reduce pain by reducing anxiety (Finlay & Anil, 2016; Nilsson et al., 2001; Nilsson et al., 2003).

*Absorption and distraction.* It has been proposed that music may serve as a cognitive distraction from pain (Good, 1996; Good et al., 1999; Mitchell & MacDonald, 2006; Mitchell, MacDonald, & Brodie, 2006). It is also theorized that the more absorbed a person becomes in a mind-body intervention such as music or suggestion, the more distracted they are from peripheral stimuli (e.g. pain) (McCaul & Malott, 1984). It is possible that music in combination with suggestion will provide a more powerful distractor whereby individuals become more absorbed in the music and focus less on the pain.

*Perceived control.* Self-efficacy has been shown to influence perception of pain, rates of disability, and pain interference (Ahlstrand, Vaz, Falkner, Thyberg, & Bjork, 2017; Jensen, 2010), and may initiate positive coping strategies (Girodo & Wood, 1979). Turner and colleagues (2007) investigated the mediating effects of several proposed psychological variables, including pain beliefs, catastrophizing, and self-efficacy, on pain and pain interference following cognitive behavioral therapy for chronic pain. The

authors concluded that self-efficacy, operationalized as perceived pain control, accounted for the greatest proportion of total treatment effect on both outcomes (Turner, Holtzman, & Mancl, 2007). It has been recognized that feelings of powerlessness over pain increase pain perception (Turk & Okifuji, 2002). Therefore, interventions that afford patients with an increased sense of self-efficacy and control over their pain are likely to prove beneficial for long-term pain management.

*Expectancy.* Response expectancy may play an essential role in participant responding. As noted earlier, expectancy may account for a large portion of the effects of suggestion in pain (De Pascalis et al., 2002). It is theorized that expectancy will account for a portion but not all of the effects in music and suggestion for pain.

*Hypnotizability.* Hypnotizability refers to "an individual's ability to experience suggested alterations in physiology, sensations, emotions, thoughts, or behavior during hypnosis" (Elkins, Barabasz, Council, & Spiegel, 2015, p.6). It is possible that music may serve as a type of hypnotic induction whereby self-suggesting is facilitated. Trials comparing non-hypnotic suggestion to hypnotic suggestion have demonstrated that people who are highly hypnotizable respond better to hypnosis and people who are low hypnotizable respond better to non-hypnotic suggestions (Milling et al., 2005). The majority of people in the population are moderately hypnotizable (Elkins, 2016). If music does act as a type of hypnotic induction, then it would be expected that people who are highly hypnotizable would report less pain in the music plus suggestion group.

*Current Study*

The comparison of music plus suggestion to music alone on experimental pain will provide critical information regarding potential mechanisms and add to the scientific literature on the benefits of music for pain. If a combined intervention (music plus suggestion) results in a more effective pain reduction strategy, then specific parameters of the treatment can be examined in order to distill the most effective components. Is it that suggestion prior to music helps to focus attention on the music allowing for greater absorption in the music? Does music serve as a type of hypnotic induction that promotes self-hypnosis based on the suggestions given prior to the music? Do expectancies influence the effectiveness of the interventions? Is the combination of music plus suggestion more relaxing, distracting, or empowering than music alone?

This study will provide effect sizes for primary outcomes (e.g. pain: threshold, tolerance, intensity, and unpleasantness), and provide valuable information regarding the effectiveness of the combined intervention and potential mechanisms of action. This information is critical to advancing the science of music for pain and moving towards integration.

Music and suggestion are easily-adapted self-management tools that can be used in a variety of settings. Dissemination of this research has the potential to improve patient care by adding to the scientific understanding of arts-based psychosocial interventions for pain. It is the goal of this study to determine if future studies of the intervention in clinical populations are warranted and what possible mechanisms may be at work.

# CHAPTER THREE

## Materials and Methods

### *Objectives*

The objective of this dissertation is to compare the effects of music plus suggestion (M+S) to music listening alone (M) on experimental pain, and to explore the possible mechanisms of action by which M + S may influence pain. Psychological and physiological variables were explored in relation to objective and subjective pain reports. Findings from this study will be used to further conceptualize potential pathways by which music exerts its analgesic effects and provide critical information for future studies of music and suggestion on pain.

### *Specific Aims*

This dissertation has four specific aims:

*Aim 1*: Determine effect sizes of music plus suggestion (M + S) on experimental pain (e.g. threshold, tolerance, intensity and unpleasantness).

*Hypothesis 1: The music plus suggestion* (*M + S*) *group will demonstrate reduced cold pressor pain compared to baseline.*

*Aim 2*: Compare the effects of music plus suggestion to music alone and no-treatment control on experimental pain.

*Hypothesis 2: Music in combination with suggestion will reduce pain reporting and increase pain tolerance over and above music, and both interventions will be superior to a no-treatment control on cold pressor pain.*

*Aim 3*: Explore potential mechanisms of M+S (e.g. relaxation, distraction, absorption, anxiety, mood, perceived control, expectancy, and hypnotizability).

*Hypothesis 3: Relaxation, perceived control, mood, and anxiety will explain part of the effect of M+S on pain.*

*Hypothesis 4: Participants receiving M + S will report higher levels of absorption and distraction than those receiving music alone.*

*Hypothesis 5: Expectancy of pain will be related to pain outcomes and will account for some of the observed effects in both M and M+S conditions. Expectancy will be linearly related to pain experience, with higher expectancy of pain resulting in higher self- reported pain and lower pain threshold and tolerance.*

*Hypothesis 6: Hypnotizability will be positively related to increases in pain tolerance and negatively related to reported pain reduction in M+S group.*

*Aim 4*: Examine the effect of music and suggestion on heart rate and blood pressure.

*Hypothesis 7: Participants in the music and suggestion condition (M+S) will show less cardiovascular responding to the cold pressor test than those in the music (M) or control (NT) conditions.*

*Sample Size and Power Analysis*

Sample size was based on a power analysis that indicated a sample of 66 participants would be sufficient to detect a large effect ($d = 0.80$) at an alpha level 0.05 and a power of 0.80 (Faul, Erdfelder, Buchner, & Lang, 2013). Previous research using music on experimental pain indicates a sample of 20 participants per group would be sufficient to detect a small effect ($d = 0.2 – 0.5$) (Hekmat & Hertel, 1993).

*Participants*

Participants were recruited from a Central Texas university through an online research participation system (SONA) and flyers posted on campus. Participants were informed that the procedure would involve placing their dominant hand in ice water and

that they would be randomized to receive one of three interventions (M + S, M, NT). Participation was compensated with course credit and/or a $5 gift card. Eligibility was based on the following criteria:

*Inclusion criteria:*

- Female
- Age 18 – 45 years
- Medically healthy as determined by medical history
- English speaking
- Non-depressed as determined by the Patient Health Questionnaire (PHQ-4) scores ≤ 9 (Kroenke, Spitzer, Williams, & Lowe, 2009)
- Signed informed consent

*Exclusion criteria:*

- Regularly taking medications for pain, depression, or anxiety (over the counter or prescribed)
- Reynaud's disease
- Prior experience with or currently using hypnosis
- Currently experiencing pain (chronic)
- Currently pregnant
- Severe or unstable medical or psychiatric illness
- Any cardiovascular or neuroendocrine disorder (e.g. diabetes, hyper/hypotension, circulatory disorders)
- Baseline pain tolerance < 10 seconds, or > 180 seconds (Staats et al., 1998).

One hundred and fifty-four individuals completed online and phone screening. Of those screened, 90 were ineligible, declined to participate, or withdrew because of personal reasons (e.g. no transportation, illness, time). This resulted in a final sample of 64 individuals who were randomized in the study. Data was excluded from one participant due to misrepresentation of eligibility that was subsequently disclosed. Using an intent to treat design, this resulted in an $N = 63$ analytic sample. Participant flow through the study is outlined in Figure 2.

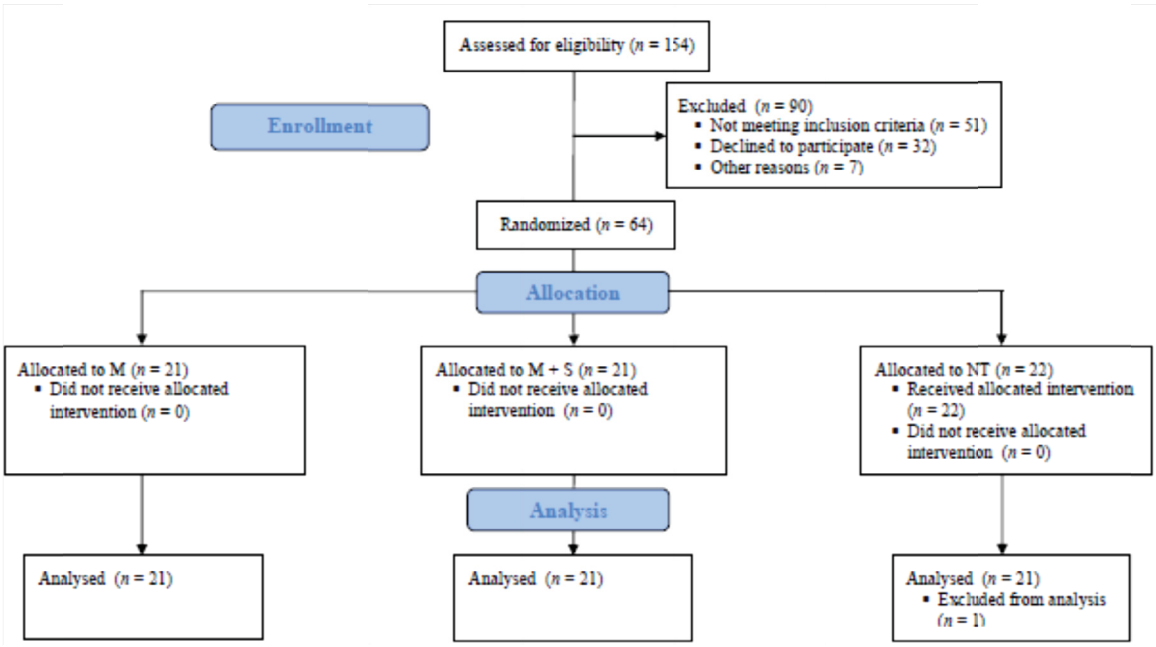


*Figure 3.1.* Participant Flowchart

The majority of participants identified as Caucasian (73%), with a family income of $75,000 or more (65 %). Most participants' parents had some college experience (88%) and did not have difficulty paying for basic necessities (82 %). Of those who reported playing a musical instrument, the average length of time they had played was 8.6 years (*SD* = 4.7), with piano (13), voice (11), and violin (4) being the most common. The average number of years participants had received musical training was 5.77 (*SD* = 4.3). Of the 37 participants who reported playing a musical instrument, 18 still actively played that instrument. On average, participants listened to music 14.79 (*SD* = 10.2) hours per week. Participants were asked to select their three favorite genres from a provided list that included the options: Classical, New Age, Country/Western, Alternative/Punk, 60's/70's Rock, Rap/Hip hop, Gospel/Christian, Jazz, Rock, World, Funk, Reggae, Folk, and Blues. The top chosen genres were Rap/Hip hop (29 votes), Gospel/Christian (25

votes), Alternative/Punk (18 votes), New Age (14 votes), Country Western (13 votes) and Classical (11 votes). Participants reported listening to music most often while driving, exercising, studying and relaxing with friends.

Chi-square tests and one-way ANOVAs were used to determine significant differences among intervention groups on demographic items. Analyses indicated there were no statistically significant differences among groups on ethnicity, race, socioeconomic status (i.e., parental income, difficulty paying for things and education level of parents), exercise, or sleep (i.e., number of hours and quality). In addition, there were no significant differences among groups in the number of participants who had played a musical instrument, received musical training, their preferred musical genres, or the number of hours per week that participants listened to music. Table B.1, Appendix B, provides full demographic composition of the total analytic sample, each treatment group and those not included in the analytic sample.

*Intervention*

*Music plus suggestion (M+S).* The M+S condition consisted of approximately 3 minutes of therapeutic suggestions for pain reduction, comfort, absorption, relaxation, and positive feelings followed by 15minutes of instrumental music (*Fantasia on a Theme of Thomas Tallis* by Ralph Vaughn-Williams). The intervention was delivered through noise-cancelling headphones plugged and a laptop. The script of recorded suggestions is located in Appendix A.

*Music (M).* The M condition consisted of listening to the same 15-minute exert of instrumental music (*Fantasia on a Theme of Thomas Tallis* by Ralph Vaughn-Williams) without suggestions. The music intervention was delivered in the same manner as the M+S condition.

*No treatment control (NT).* In this condition, participants were treated the same as in the other two conditions. Participants wore noise-cancelling headphones while listening to a 15-minute recording of silence that was created using version 2.2.1 of Audacity ® recording and editing software (Audacity ®, 1999- 2018).

## *Measures*

### *Screening Measures*

*Patient health questionnaire.* The Patient Health Questionnaire for Depression and Anxiety (PHQ-4) was used to determine eligibility prior to study enrollment. The PHQ-4 is a 4-item screener for depression and anxiety that has been demonstrated to be a valid and brief tool for detecting both anxiety and depressive disorders (Kroenke et al., 2009).

S*creening questionnaire.* All participants complete a screening questionnaire prior to study participation. Participants were asked to respond by circling "yes" or "no" to each question. The questionnaire consisted of 11 items based on the previously described eligibility criteria (e.g., medical conditions, medication, use of hypnosis), and assessed general health and the presence of a current pain condition, psychiatric illness,

pregnancy, or other health conditions that could place them at an increased risk of adverse events related to the cold pressor procedure or hypnosis.

*Baseline pain tolerance.* Prior to randomization, participants were asked to complete a cold pressor trial to establish a baseline measure and to screen according to exclusion criteria. Participants that did not reach a minimum time of 10 seconds or exceeded a maximum time of three minutes were excluded from further participation.

*Study Measures*

*Demographics.* Participants were asked to complete a 15-itme demographic questionnaire (e.g. age, SES, ethnicity, activity level, and hours of sleep last night, quality of sleep, musical training, and preferred musical genres) prior to study procedures.

*Pain threshold.* Pain threshold is "the lowest intensity of a painful stimulus at which the subject perceives pain" (Farlex, 2012). To measure pain threshold during cold pressor trials, participants were asked to indicate "when and if" they first experienced pain by saying "now." Pain threshold was measured in seconds during the baseline and intervention cold pressor trials. Pain threshold refers to the time (in seconds) from hand immersion to the participant's report of discomfort.

*Pain tolerance.* Pain tolerance was defined as the total time (in seconds) that the hand was immersed in the cold pressor. Pain tolerance has been previously conceptualized as the length of time a person is willing to endure cold pressor pain (Nielsen, Staud, & Price, 2009), and is thought to be influenced by motivation and psychosocial factors (Feldner & Hekmat, 2001).

*Pain intensity.* Self-reported pain intensity was measured using a 100 mm visual analog scale (VAS-PI) anchored at 0 (no pain) and 10 (worst possible pain). Participants were asked to self-report their current felt pain intensity before and immediately after each cold pressor trial by placing a mark on the horizontal line. The VAS score could range from 0 to 10 and was determined by measuring the distance from the left hand side end of the line to the place where the participant marked the line. This procedure was also used in all subsequent VAS measures. VAS measures have been demonstrated to be reliable and valid measures of experimental pain (Price, McGrath, Rafii, & Buckingham, 1983; Price and Harkins, 1987), and have been shown to discriminate between pain sensation intensity and pain unpleasantness (Price and Harkins, 1987, 1992; Price et al., 1983, 1987). In addition, VAS instruments have been demonstrated to have ratio properties and are considered accurate indicators of percent changes in clinical pain (Price et al., 1983; Price, Bush, Long, & Harkins, 1994).

*Pain unpleasantness.* Self-reported pain unpleasantness was measured on a 100 mm visual analog scale (VAS-PU) with anchors at 0 (not at all unpleasant) and 10 (the most unpleasant imaginable) (Price et al., 1994; Price, 1999). Pain unpleasantness was described to participants as "how unpleasant or disturbing the pain is" (Price et al., 1983, p. 47). Participants were asked to place a mark through the line to indicate pain unpleasantness before and immediately following each cold pressor trial. Price and colleagues (1983) determined that the pain unpleasantness visual analog scale was a valid and discriminating measure of the affective magnitude of experimental and clinical pain.

*Anxiety.* The State-Trait Inventory for Cognitive and Somatic Anxiety (STICSA; Ree, MacLeod, French, & Locke, 2000; Ree, French, MacLeod, & Locke, 2008) was used to assess cognitive and somatic symptoms of anxiety at both the trait (in general) and state (at this very moment) level. The STICSA consists of two 21-item scales with identical items; one to assess trait anxiety and one to assess state anxiety. Each scale contains two subscales: a 10-item cognitive anxiety subscale and an 11-item somatic anxiety subscale (Roberts, Hart, & Eastwood, 2016). Items are rated on a 4-point Likert-type scale ranging from 1(not at all) to 4(very much so), and summed. Scores can range from 10-40 (cognitive subscale), 11-44 (somatic subscale) and 21-84 (total scale), with higher scores indicating more of the construct. The STICSA exhibits good internal consistency ($\alpha s \geq 0.92$), convergent validity other measures of anxiety (*STAI,* $r = .66$; *DASS,* $r = .68$) and divergent validity with other validated measures of depression ($rs \leq .61$) (Grös, Antony, Simms, & McCabe, 2007; Ree et al., 2008).

Trait anxiety was assessed during the intake process prior to the cold pressor trials. State anxiety was assessed immediately after each cold pressor trial. In addition to the STICSA, an anxiety visual analog scale (VAS-A) was also administered to assess state anxiety. Participants were asked to "Please put a mark through this line to indicate how anxious you are right now" with anchors from 0 (not at all anxious) to 10 (as anxious as I can be) before and immediately after each cold pressor trial. The single-item VAS-A correlated significantly with the Spielberger State Trait Anxiety Inventory (STAI; Spielberger, 2010; $r = 0.50$) but not with the Beck Depression Inventory (BDI; Beck, Steer, & Brown, 2006; $r = 0.13$) in a validation study of preoperative anxiety

(Facco et al., 2013). It is thought that the VAS-A provides an overall measure of anxiety in medical settings (Facco et al., 2013).

*Relaxation.* Relaxation was subjectively reported on a 10cm visual analog scale (VAS-R) before and immediately following each cold pressor trial. Participants were asked to "Please put a mark through this line to indicate how relaxed you are right now" with the anchors from 0 (not at all relaxed) to 10 (as relaxed as I can be). The VAS-R has been shown to be a valid and sensitive measure of self-perceived anxiety in healthy individuals (Urech et al., 2010).

*Mood.* Affect and emotional state were measured following each cold pressor trial using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988) and a one-item visual analog scale (VAS-E). The PANAS is a 20-item self-report measure of positive (10 items) and negative (10 items) affect. Participants were asked to rate descriptors of positive (e.g. "interested") and negative (e.g. "afraid") affect using numbers ranging from 1(very slightly) to 5(extremely) to indicate how they felt "at the present moment". Items are summed for each subscale to produce total positive and negative affect scores.

The positive and negative subscales of the PANAS have been demonstrated to be internally consistent, $\alpha$'s $\geq .84$, and reliable, $r$s $\geq .54$ -.68 and .45 -.71, respectively (Leue & Lange, 2011; Watson et al., 1988). In addition, participants were asked to rate their current emotional state on a 100 mm visual analog scale (VAS-E), with the instructions "Please put a mark through this line to indicate right now how emotionally upset you feel

right now" anchored at 0 (not at all upset) to 10 (as upset as I could be) (Montgomery et al., 2010).

*Perceived control.* Perceived pain control was measured using a 100 mm visual analog scale. Participants were asked to indicate "How much did you feel you had control over the pain?" by placing a mark on the horizontal line. The scale was anchored at 0 (no control at all) to 10 (complete control).

*Distraction.* Distraction from pain was measured using a visual analog scale (VAS-Dis) following the intervention cold pressor trial. Participants were asked to make a mark on a 100 mm horizontal line to indicate "During this trial, how distracted from the pain were you?" The scale was anchored at 0 (not distracted at all) to 10 (extremely distracted).

*Absorption.* A visual analog scale of absorption (VAS-Ab) in the intervention was administered following the final cold pressor trial. Participants were asked to rate "How absorbed were you in the music?" by placing a mark on a 100 mm horizontal line with the anchors 0 (not at all absorbed) and 10 (completely absorbed). Participants in all groups were asked to respond in order to maintain experimenter blinding.

*Pain expectancy.* Based on the methods of previous research, pain expectancy was rated at two time points to fully explore the role of response expectancies in pain reporting (Milling et al., 2005). Expected pain intensity was assessed following the baseline cold pressor trial, prior to and following randomization, using two different 100 mm visual analog scales. After participants completed baseline pain intensity,

unpleasantness, anxiety and mood questionnaires, they were asked to indicate "On the next trial, how much pain do you expect to feel?" by marking a horizontal line anchored at 0 (no pain at all) and 10 (as much pain as there could be), to indicate what they expected the pain to be like during the next cold pressor trial. Expectancy was again assessed after participants had experienced the intervention for approximately four minutes. While listening to the intervention, participants in all groups were asked to rate "Based on the intervention you will receive, on the next trial, how much pain do you expect to feel?" with anchors at 0 (no pain at all) and 10 (as much pain as there could be). All participants, regardless of group, were asked to rate this question prior to the second cold pressor trial.

*Cardiovascular monitoring.* Participant blood pressure, systolic (SBP)/diastolic (DBP), and heart rate (HR) were recorded for 20 minutes prior to the first cold pressor trial to establish a resting baseline. Assessments were taken at 15 seconds (sec.), 1 minute (min.) 45 sec., 3 min. 15 sec., 4 min. 45 sec., 10 min., 15 min., 16 min. 30 sec., 18 min., and 19 min. 30 sec. The last two assessments were averaged to produce a resting baseline. SBP/DBP and HR were assessed at 5 sec, 40 sec (if applicable) and immediately upon withdrawal during both cold pressor trials. To ensure that participants returned to resting baseline values between the two cold pressor trials, SBP/DBP and HR measurements were taken 10, 15, 18, and 20 minutes following the first cold pressor trial. The final two measures during this rest period were averaged for a measure of recovery.

SBP/DBP and HR were recorded using an Omron HEM-780 automatic blood pressure monitor. This device has been tested according to the standards of the European Society of Hypertension (ESH) and the Association for the Advancement of Medical

Instruments (AAMI), and has met the criteria of both these protocols and is considered to be a clinically validated instrument (Viera & Hinderliter, 2007; Wan et al., 2010). The cuff was placed on the non-dominant arm. In addition, HR data was also collected using the Biopac Nomadix 150 ECG transducer and electrodes. Electrodes were positioned in a Lead II configuration (i.e., Einthoven's triangle: positive lead on lower left rib, negative lead under right collarbone, ground lead under left collarbone).

*Hypnotizability.* Hypnotizability was measured at the end of the study period, following the completion of all other study procedures and questionnaires as to not influence participant responding during the intervention cold pressor trial. Hypnotizability was assessed using the Elkins Hypnotizability Scale (EHS; Elkins, 2014). The EHS has been shown to be a reliable and valid measure of hypnotizability in the general population with the ability to discriminate between low, medium, high and very high hypnotizables (Elkins, 2014).

### *Apparatus*

A thermal cooler filled with water and crushed ice was used as the cold pressor (CP). The duration of hand submersion in the CP was measured in seconds using a calibrated stopwatch. Water was circulated using a Homasy 400GPH submersible pump. Water temperature was continuously monitored with two RISEPRO digital water thermometers and maintained at (1 ± 0.2 °C). Hand temperature was assessed using a clinical digital thermometer. Interventions were delivered using Bose noise cancelling headphones connected to a laptop (Toshiba). The interventions were played on the laptop using Windows Media player.

### *Randomization*

Randomization was conducted using an online program (i.e., Sealed Envelope, LTD; 2017) using varying block sizes of 3 and 6. Randomization codes were kept in an opaque sealed envelope until after data entry was complete and verified, at which point group assignment was entered as a final column in the data file. Participants were randomly assigned to receive music (M), suggestions followed by music (M+S), or a no-treatment control (NT) following baseline cold pressor test. Each participant's chart had been previously prepared by a research assistant blind to the study hypothesis and meaning of the randomization codes. Treatment groups (i.e. M, M+S, NT) were assigned via a numerical code (e.g. 1, 2, & 3). An uninvolved research assistant randomly assigned the interventions' codes prior to the study. The experimenter remained blind to the meaning of the codes until after the full study was completed and all data was entered.

### *Blinding*

The experimenter remained blind to the participant's condition throughout the trial. Research assistants who prepared the charts and randomization codes were blind to the study hypothesis or the meaning of the randomization codes. Data entry was conducted by research assistants blind to the research hypothesis or treatment conditions of the participants. Each intervention was labeled using codes and participants were instructed not to reveal which intervention they were listening to during the trial. Interventions were previously coded by a research assistant.

## *Procedures*

### *Informed Consent*

The Baylor University ethics committee (IRB) approval was sought prior to study implementation. Potential participants were provided with an explanation of the study and written informed consent prior to enrollment. Each consenting participant received a copy of their signed informed consent for their records.

### *Recruitment and Screening*

Sixty-six participants were recruited through an online system at Baylor University designed to provide extra class credit in return for study participation (e.g. SONA) and through campus advertisements. Screening for inclusion in the study occurred in two phases. During the first phase, interested students were screened through an online survey or by phone according to eligibility criteria (i.e., PHQ-4, screening questionnaire). Participants who were screened over the phone were provided with the opportunity to verbally consent prior to the screening interview. Participants who completed the online screening survey did so through the SONA system.

The second screening phase occurred during the laboratory visit. Participants were screened on pain tolerance during the first cold pressor trial. Participants unable to reach the minimum (10 sec.) or exceeding the maximum (300 sec.) cold pressor tolerance times were excluded from the remainder of the experiment.

### *Study Procedures*

Once potential participants were screened according to the PHQ-4 and screening questionnaires, they made an appointment to visit the lab to complete the study. Potential

participants were asked to abstain from caffeine, nicotine, alcohol, drugs, and exercise for 24 hours prior to their lab appointment.

Once at the lab, participants were asked to complete written informed consent and pre-baseline questionnaires (e.g. demographic, STICSA-Trait, VASs-PI, PU, A, R) in a quiet and private room. Any questions participants had about the study were answered by the experimenter at this time. After the pre-baseline questionnaires were completed, participants were shown to the study room where they were fitted with ECG electrodes and the blood pressure cuff (non-dominant arm) by the experimenter.

Participants were seated comfortably and monitored (e.g. heart rate, blood pressure) for 20 minutes prior to the baseline cold pressor trial. Participants were asked to not cross their legs at the ankle or knee and were not allowed to engage in any activities that could cause changes in blood pressure (e.g. smart phone, homework, smart watch) and conversation was kept to a minimal. Hand temperature was taken approximately 10 minutes prior to the first cold pressor trial using a digital thermometer (Mitchell, MacDonald, & Brodie, 2004). The experimenter sat behind the participant throughout the study to minimize her potential influence on participant's reactions.

A sound check was conducted on the headphones during the pre-baseline rest period to ensure participant volume preference and comfort. The sound check consisted of a random selection of classical instrumental music. Participants were given standardized instructions on how to complete the cold pressor trial (e.g. *submerge hand up to wrist and take hand out when you can no longer take it*) and instructions on how to report pain threshold ("*say NOW, if and when you first experience pain*"), and pain tolerance ("*say STOP and pull your hand out of the water when you can no longer*

*tolerate it).* The cold pressor apparatus was shown and explained to participants prior to the first trial (e.g., purpose of aquarium pump and thermometer, and how the water temperature was maintained). After the pre-baseline rest period was completed, the experimenter instructed the participant to begin the first cold pressor. An uninformed time limit of three minutes was implemented to ensure participant safety.

After participants completed the first cold pressor trial (i.e. baseline) they were immediately asked to complete self-report measures of pain intensity, pain unpleasantness, anxiety, relaxation (VASs) and scales of mood (PANAS, VAS-E), anxiety (STICSA-State) and expectancy (VAS). Blood pressure and heart rate were monitored during the trial and immediately upon hand withdrawal, as previously described (see *Measures*). Participants were then provided with a heating pad to return their hand to baseline temperature. Once baseline hand temperature was regained, the heating pad was removed. Blood pressure and heart rate monitoring continued as described during the between-trial rest period.

Participants that fell within the pre-specified minimum and maximum cold pressor time limits (i.e. 10 – 180 seconds) were then randomized to one of the three treatment conditions (M+S, M, and NT) during the between-trials rest period. The experimenter opened a sealed opaque envelope that was attached to the participant's chart in front of the participant. Each envelope contained a code that corresponded to the appropriate treatment condition. Envelopes had been prepared in advance by a uniformed research assistant according to a computerized randomization schedule.

The experimenter told participants that she "did not know what the codes meant and did not want to know" and repeated the possible treatment conditions that they could

receive. The experimenter reiterated that they were to not tell her what they were listening to at any time during the study and reminded participants of the previous sound check, saying "we know the headphones work, so if you hear nothing, please accept that is the treatment condition you are in and do not tell me that you 'hear nothing.'" The laptop used to deliver the music interventions had three numerically coded icons corresponding to each intervention condition. The icons were prepared in advance by a research assistant and unknown to the experimenter. Participants were shown the icons to further corroborate that the experimenter would not know what they were listening to.

The experimenter explained that participants would complete VAS scales (e.g., Treatment Expectancy, VAS-PI,VAS-PU,VAS-A, VAS-R) approximately three minutes after the intervention started and be signaled (by a tap on the shoulder) to begin the second cold pressor trial approximately10 minutes after the intervention started. This procedure ensured that listening to the intervention would remain relatively uninterrupted. Standardized instructions on how to report pain threshold and pain tolerance were repeated.

Fifteen minutes into the between-trial rest period, participants were handed the headphones to begin listening to the intervention. Fifteen minutes has been demonstrated to be adequate for cardiovascular recovery following cold pressor (Saab et al., 1993). Once the headphones were comfortably in place, the experimenter started the intervention by clicking on the coded icon on the computer screen. Participants completed VAS scales and the second cold pressor trial as described. Blood pressure and heart rate were monitored as described previously. Once the cold pressor trial was completed, the researcher stopped the intervention and the participant reported pain intensity, pain

unpleasantness, relaxation, and anxiety (VASs) and completed a battery of psychological measures (e.g., PANAS, STICSA-State, VAS-E, VAS-PC, VAS-Ab, VAS-Dis). Participants were offered a heating pad for comfort. Hypnotizability was assessed using the EHS after the participant was once again comfortable.

*Research Design*

Participants were participants randomly assigned to one of three groups (M+S, M, or NT). Participants in all groups were tested two times on pain outcomes pre – and post-intervention. This type of research design, in which each participant essentially serves as her own control, allows for estimates of treatment effectiveness to be computed even if groups are nonequivalent prior to testing (Cook & Campbell, 1979; Morris & DeShon, 2002).

## *Data Management*

Participant data was de-identified upon entry to the study. Each participant was assigned a unique and random identification code. Code lists were kept in a locked file cabinet away from participant data. All data was entered into an SPSS file by two research assistants who were blind to study hypotheses or group assignment. Data was verified after every fourth entry by the researcher, who was also blind to group assignment. After all participant data was entered and verified, group assignment was added to the data set.

*Data Inspection*

Prior to any analysis, data was inspected for outliers, unlikely scores, missing data, and assumptions. Visual inspection of histograms, quantile-quantile (qq) plots,

scatterplots, boxplots, and specific statistical tests (e.g., Cook's distance, Hat-values, Levene, Shapiro-Wilk) were used to assess the data for normality, linearity, outliers, and homoscedasticity of variance and regression slopes. Log transformations (i.e., log (e)) were applied to pain threshold and pain tolerance data to correct for skewness and outliers. Visual inspection of regression slopes indicated the assumption of homogeneity of regression slopes was met. Other assumptions, including normality of residuals and homogeneity of variance, were tenable.

*Missing Data*

The total amount of missing data for the analytic sample was 3.6%. The largest percentages of missing data were due to equipment failure (i.e., SBP/DBP). Based on the pattern of missing data it was assumed that data were missing at random (MAR) for every variable except cardiovascular readings for the 40 second assessment point. As these data points were a function of individual pain tolerance, they were considered to be missing not missing at random (NMAR) and were not imputed. For all other variables, the Multivariate Imputation by Chained Equations package (mice; van Buuren, & Groothuis-Oudshoorn, 2010) in R (v. 3.5.0), generated 3 imputed datasets, using 'predictive mean matching' (pmm) with max iterations set to 15, seed 56587. Items missing for individual scales were imputed prior to calculating total scores (i.e., PANAS, STICSA-T, STICSA-T) (Schlomer, Bauman, & Card, 2010), and based on the information available from other individual items in the data set. Imputed datasets were pooled according to Rubin's (1987) rules. Trace plots and imputed data sets were visually inspected prior to pooling and provided evidence of convergence. Table B.2 presents the full pattern of missing data.

*Data Analyses*

All data was analyzed using SPSS v.24 and R (3.5.0). One way analysis of variance (ANOVAs), Chi-Square tests, and *t* tests were conducted to examine group differences in demographics and relevant outcomes. Within-group effects for repeated measures (Morris & Deshon, 2002) were computed for all treatment groups, based on the within group mean difference, standard deviation and correlation. Analysis of covariance (ANCOVA) was used to compare the effects of M + S to M and M to NT on all four pain outcomes (e.g. threshold, tolerance, intensity, unpleasantness), with baseline pain (covariate) and orthogonal contrasts to compare the treatment effects entered as predictors (*Aim 1* & *Aim 2*). The relationships between potential mechanisms (e.g., expectancy, anxiety, relaxation, mood, control, distraction, and absorption) and pain outcomes were explored using correlations (*Aim 3*). *Resting* (e.g. pretrial) baseline and intervention blood pressure (BP) and heart rate (HR) were computed by taking the average of the final three measurements during the two rest periods, respectively. BP and HR *reactivity* scores were computed as the difference between the average of three values obtained during the resting period from the average of the values obtained during the cold pressor trials (i.e. *trial – resting*) (Ginty & Conklin, 2012). One-way ANCOVAs were used to analyze differences among groups in cardiovascular reactivity during the intervention trial, controlling for resting BP and HR (*Aim 4*).

# CHAPTER FOUR

## Results

Objective measures of pain (e.g. pain threshold and pain tolerance) were not significantly correlated with subjective reports of pain (VAS-PI and VAS-PU), *p*s > 10. However, pain threshold and pain tolerance were significantly correlated with each other (*r* = .63), as were pain intensity and pain unpleasantness (*r*s = .78 - .86), in the overall sample. These relationships also held in the two intervention groups, (M: pain threshold and pain tolerance, $r = .67$, $p < .67$; pain intensity and pain unpleasantness, $r = .92$, $p < .001$; M+S: pain threshold and pain tolerance, $r = .50$, $p < .05$; pain intensity and pain unpleasantness, $r = .88$, $p < .001$). Despite the high correlations between VAS-PI and VAS-PU scores, the results indicated that participants were able to discriminate between pain intensity and pain unpleasantness. Therefore, the two VAS scales were considered as unique pain identifiers in all analyses.

Within-group effect sizes were computed for each group using Morris & Deshon's (2002) repeated measures effect size equation (Equation 8; p.109):

$$d_{\mathrm{RM}} = \frac{\mu_D}{\sigma\sqrt{2(1-\rho)}} \ ,$$

where $\mu_{\mathrm{D}}$ is the mean difference between posttest minus pretest scores, $\sigma$ is the standard deviation of pretest scores (Morris, 2008), and $\rho$ is the correlation between pre- and posttest scores. Pretest standard deviations are recommended when calculating repeated measures effect sizes in order to control for potential participant by treatment effect

interactions within groups (Morris, 2008). This procedure was used to assess within-group changes in pain responses from baseline to intervention cold pressor trials. These data are presented in Tables 4.1 and 4.2.

Participants in the M + S condition ($d_{RM}$ = 0.83, 95% CI [.20, 1.46], and M condition ($d_{RM}$ = 1.9, 95% CI [1.17, 2.63], had a statistically significant changes in pain tolerance from baseline to intervention. Participants receiving M + S changed significantly in self-reported pain unpleasantness from baseline to intervention, $d_{RM}$ = -0.73, 95% CI [-1.35, -0.11], (*Table 4.2*).

Table 4.1. *Pain Threshold and Pain Tolerance across Groups*

| | Outcome | Baseline *M*(*SD*) | Intervention *M*(*SD*) | Baseline* *M*(*SD*) | Intervention* *M*(*SD*) | $d_{RM}$** | 95% CI [UB,LB]** |
|---|---|---|---|---|---|---|---|
| NT | Pain Threshold | 14.67 (17.4) | 18.57 (33.53) | 2.34 (.76) | 2.37 (.88) | 0.08 | [-.53,.69] |
| | Pain Tolerance | 35.90 (33.90) | 41.30 (42.38) | 3.32 (.68) | 3.39 (.75) | 0.26 | [-.35,.87] |
| M | Pain Threshold | 10.66 (6.09) | 14.99 (10.91) | 2.23 (.52) | 2.46 (.73) | 0.57 | [-.05,1.19] |
| | Pain Tolerance | 32.11 (22.73) | 55.10 (62.85) | 3.28 (.60) | 3.64 (.81) | 1.9 | [1.17,2.63] |
| MS | Pain Threshold | 13.61 (12.88) | 20.12 (21.75) | 2.31 (.75) | 2.64 (.79) | 0.42 | [-.19,1.03] |
| | Pain Tolerance | 31.76 (18.85) | 48.03 (42.29) | 3.32 (.52) | 3.58 (.77) | 0.83 | [.20,1.46] |

*Note*: Data was missing for two baseline threshold and three intervention threshold scores. Missing data for mean threshold was imputed using multiple imputation procedures. Threshold and tolerance reported in seconds. *Indicates natural log transformed value.; **Based on log transformed values.

### *Aims 1 and 2*

Analysis of covariance (ANCOVA) was used to compare the effects of M + S to M and NT on experimental pain. Two planned orthogonal contrasts (c1= (-.66(NT) + (.33)M + (.33)M+S; c2= (0)NT + (-.5)M + (.5)M+S), and baseline pain (covariate) were entered into four separate linear models predicting pain during the intervention trial. Prior to analysis, one-way ANOVAs were conducted to detect differences among groups on

pre-baseline and pre-intervention self-reported pain intensity and pain unpleasantness. Groups were not statistically significantly different on these pain measures prior to the cold pressor trials, *p*s > 0.50.

Table 4.2. *Pain Intensity and Pain Unpleasantness across Groups*

| | Outcome | Pre-Baseline *M*(*SD*) | Baseline *M*(*SD*) | Pre-Intervention *M*(*SD*) | Intervention *M*(*SD*) | $d_{RM}$ | 95% CI UB,LB |
|---|---|---|---|---|---|---|---|
| NT | VAS-PI | .63(1.10) | 5.63 (2.08) | .31 (0.64) | 5.72 (1.74) | .048 | -.56,.65 |
| | VAS-PU | .49 (1.06) | 5.95 (2.40) | .35 (0.71) | 5.75 (2.36) | -.096 | -.70,.51 |
| M | VAS-PI | .83 (1.44) | 5.33 (2.23) | .54 (0.83) | 5.43 (2.28) | .048 | -.56,.65 |
| | VAS-PU | .71 (1.32) | 5.71 (2.22) | .49 (0.92) | 5.18 (2.34) | -.34 | -.95,.27 |
| MS | VAS-PI | .99 (1.70) | 6.15 (2.07) | .53 (0.72) | 5.49 (2.34) | -.44 | -1.05,.18 |
| | VAS-PU | .88 (1.86) | 6.80 (2.33) | .36 (0.59) | 5.40 (2.71) | -.73 | -1.35,-.11 |

*Note.* Negative effect sizes represent a positive effect (i.e., decrease in self-reported pain).

*Pain Threshold*

The effect of baseline pain threshold was statistically significant $F(1,57) = 28.56$, $p < 0.001$, (*Figure 4.1*). Baseline pain threshold was the only significant predictor of intervention threshold in the model , $\beta = 0.82$, $p < .001$. Taken together, treatment group contrasts and baseline pain threshold explained 46% ($R^2 = .52$) of the total variability in pain threshold during the intervention cold pressor trial.

*Pain Tolerance*

The results of a one-way ANCOVA indicated there were statistically significant differences in among groups when controlling for baseline pain tolerance, $F(2,57) = 3.56$, $p < 0.05$. Baseline pain tolerance was a statistically significant predictor of intervention pain tolerance, $\beta = 0.78$, $p < .001$. Planned orthogonal contrasts indicated that M and M + S improved pain tolerance compared to NT, $\beta = 0.37$, $p < 0.05$, (*Figure 4.2*), but that M + S was not statistically significantly better than M at improving pain

tolerance when controlling for baseline pain tolerance. The overall model explained 81% ($R^2 = .81$) of the variability in pain tolerance during the intervention cold pressor trial.

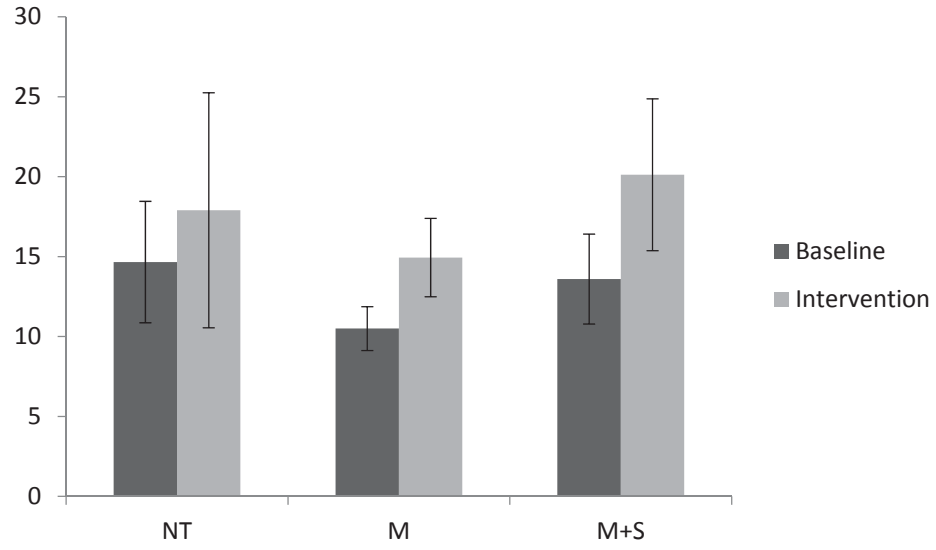


*Figure 4.1.* Pain threshold by group, in seconds (raw data). *Note:* Error bars show standard error of the mean.

*Pain Intensity*

Self-reported baseline pain intensity accounted for a statistically significant portion of the variance in pain intensity reported during the intervention cold pressor, $F(1,57) = 7.70$, $\beta = .50$, $p < 0.01$. There were no other statistically significant predictors in the model. The model accounted for approximately 42% ($R^2 = .42$) of the variability in self-reported pain intensity during the intervention cold pressor trial, (*Figure 4.3*).

*Pain Unpleasantness*

The results of a one-way ANCOVA with group (orthogonal contrasts) comparisons controlling for baseline pain unpleasantness did not indicate a statistically significant effect of group on intervention pain unpleasantness. Baseline pain unpleasantness was statistically significant for predicting intervention pain

unpleasantness, $F(1,57) = 48.25, \beta = .58, p < 0.001$. The overall model explained approximately 46% of the variability in self-reported pain unpleasantness during the intervention cold pressor trial, ($R^2 = .46$), (*Figure 4.4)*.

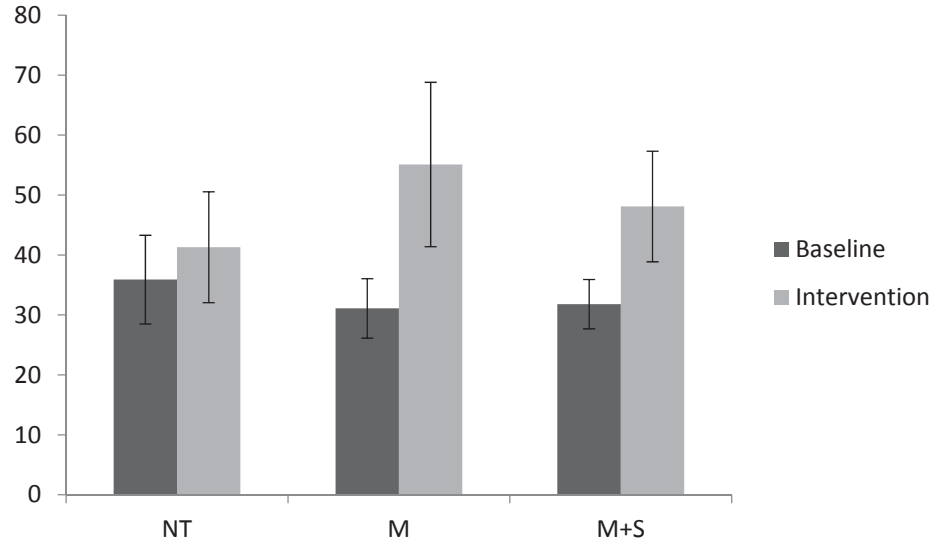


*Figure 4.2.* Pain tolerance by group in seconds (raw data). *Note:* Error bars show standard error of the mean.

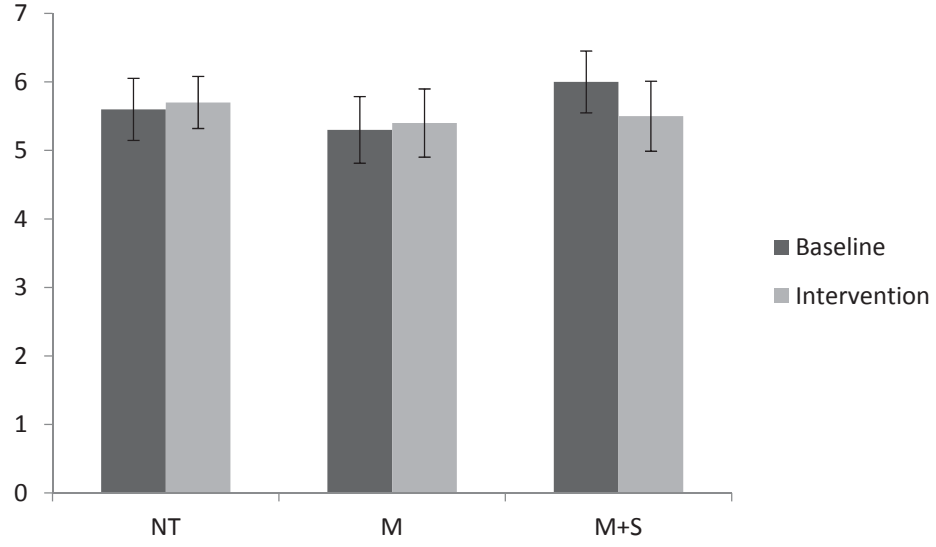


*Figure 4.3.*Pain intensity by group. *Note:* Error bars show standard error of the mean.

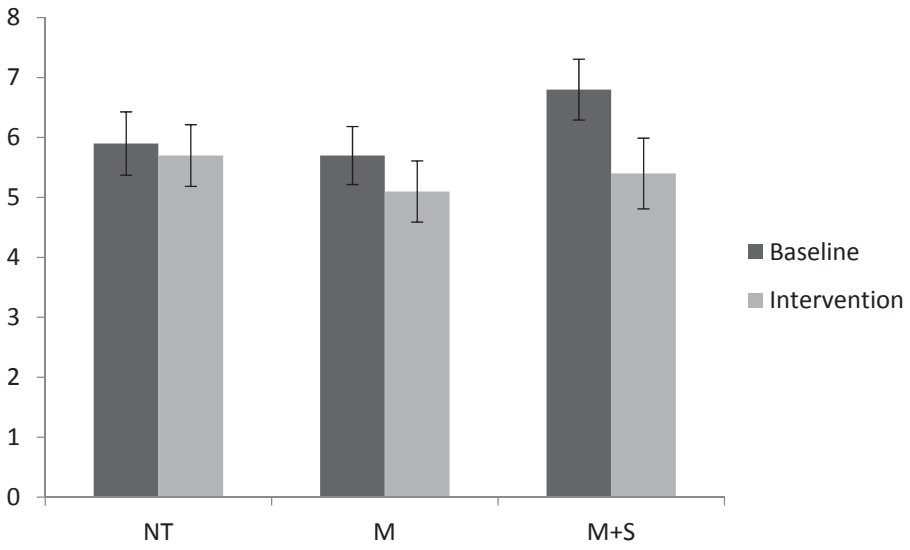


*Figure 4.4.* Pain unpleasantness by group. *Note:* Error bars show standard error of the mean.

*Aim 3*

Pearson correlations were used to explore potential relationships among measured variables and pain tolerance in the M and M + S groups. Analyses were conducted for each group separately. In the M group, treatment expectancy ($r$ = -.57, $p$ < .01), and distraction ($r$ = .48, $p$ < .05), were statistically significantly related to pain tolerance during the intervention cold pressor trial. There were no statistically significant relationships for the M + S group among proposed mechanisms and pain tolerance during the intervention.

In addition, correlations were computed for each intervention type (e.g. M or M + S) among all pain outcome variables (e.g., threshold, tolerance, intensity, unpleasantness). Pain intensity and pain unpleasantness were highly correlated in both intervention groups ($r$ = .87-.92, $p$ < .001). Pain threshold and pain tolerance were also statistically significantly related in both intervention groups ($r$ = .50 - .67, $p$ < .05).

Hypnotizability scores (EHS) for the M + S group showed nine participants scored in the "Low" range (0-3), nine scored in "Middle" range (4-8), and three scored in the "High" range (9-10) (Elkins, 2014). On average, participants found the EHS experience to be pleasant ($M$ = 7.2) on a 0 – 10 VAS, with higher scores indicating more pleasant feelings. When asked "how deeply hypnotized you felt you were at the deepest during this assessment", participants responded on average 4.65(*3.2*), on a 0 – 10 VAS. When asked if they would like to be contacted in the future to participate in other hypnosis research projects, 65% of the Group 3 participants responded "yes". Spearman rank correlations indicate hypnotizability was not statistically significantly related to pain outcomes during the intervention cold pressor trial ($r_s$ = -0.2 - 0.15, $p$s = .38 - .67). However, hypnotizability was statistically significantly related to absorption ($r_s$ = .44, $p < .05$). This positive relationship was not present in the NT or M groups.

*Aim 4*

One-way ANCOVAs were used to compare cardiovascular responses to cold pressor during the intervention trial among groups, controlling for resting BP and HR. Paired samples *t* tests indicated in the whole sample, there was a statistically significant increase in BP and HR from rest to task for both cold pressor trials, $p < .001$, *Table 4.3.* A series of one-way ANOVAs revealed participants did not differ significantly at during either rest period on SBP or DBP. There was a statistically significant difference among groups on baseline resting HR, $F(2,60) = 4.12$, $p < .05$. HR was not statistically different among groups for intervention resting HR. In addition, there were no statistically significant differences among groups on cardiovascular reactivity for the baseline trial.

Table 4.3. *Overall Cardiovascular Responding to Cold Pressor Trials*

| Trial | Outcome | *Mean Diff* | *t* | *df* | *p* | 95% CI LL,UL |
|---|---|---|---|---|---|---|
| Baseline (trial – rest) | SBP | 10.7 (*6.6*) | 12.8 | 62 | < .001 | 9.1, 12.4 |
| | DBP | 8.3 (*6.9*) | 9.5 | 62 | < .001 | 6.5, 9.9 |
| | HR | 2.1 (*6.3*) | 2.6 | 62 | < .001 | .52, 3.7 |
| Intervention (trial – rest) | SBP | 10.4 (*7.6*) | 10.8 | 62 | < .001 | 8.4, 12.3 |
| | DBP | 8.2 (*7.2*) | 9.0 | 62 | < .001 | 6.4, 10.0 |
| | HR | 4.6 (*6.6*) | 5.6 | 62 | < .001 | 3.0, 6.3 |

*Note*: SBP/DBP in mm Hg; HR in beats per minute (BPM).

The results of the one-way ANCOVAs indicated there were no statistically significant differences between groups in SBP, DBP, or HR reactivity. There was a statistically significant covariate effect for resting HR ($\beta$ = -.51, $p$ < .01) on HR reactivity during the intervention cold pressor.

Table 4.4. *Cardiovascular Baseline and Trial Means*

| | M + S | | M | | NT | |
|---|---|---|---|---|---|---|
| Outcome | Baseline | Intervention | Baseline | Intervention | Baseline | Intervention |
| Resting SBP | 106.21 (8.0) | 106.19 (5.8) | 103.76 (5.4) | 104.04 (6.2) | 104.12 (7.3) | 104.29 (8.6) |
| Resting DBP | 74.0 (5.8) | 72.93 (5.2) | 71.0 (4.2) | 71.69 (4.5) | 73.64 (5.6) | 74.7 (5.9) |
| Resting HR | 76.5 (9.5) | 71.3 (8.3) | 68.8 (9.1) | 66.3 (9.3) | 73.5 (7.5) | 71.5 (9.3) |
| Trial SBP | 117.98 (9.5) | 101.19 (8.6) | 114.05 (8.5) | 95.86 (8.9) | 114.6 (10.9) | 100.07 (7.1) |
| Trial DBP | 82.69 (11.4) | 83.55 (8.6) | 79.6 (6.5) | 78.86 (8.3) | 81.52 (8.1) | 82.0 (7.3) |
| Trial HR | 79.4 (10.3) | 76.8 (11.5) | 71.8 (8.3) | 70.9 (8.6) | 74.7 (7.8) | 75.9 (8.4) |

*Note*: SBP/DBP in mm Hg; HR in beats per minute (BPM).

### *Ancillary Analyses*

Ancillary analyses were conducted to explore possible contributing factors to observed individual differences in baseline pain outcomes. Correlations were conducted to ascertain if multiple measures of anxiety and emotion were redundant. The results

indicated that the STICSA-Trait and the STICSA-State total scales were correlated at $r$ = .81, $p$ < .001. The VAS-A was statistically significantly correlated with the somatic subscale of the STICSA-State (STICSA-S-S), $r$ = .71, $p$ < .001, and the PANSAS-N, $r$ = .64, $p$ < .001. The PANAS-N was significantly correlated with the STICSA-S-S, $r$ = .79, $p$ < .001, and the VAS-E, $r$ = .64, $p$ < .001.

Four separate sequential regression analyses were conducted using the entire sample ($N$ =63) to predict baseline experimental pain outcomes (e.g. threshold, tolerance, intensity, and unpleasantness). Variables were selected based on theory and to reduce the potential influences of multicollinearity. Multicollinearity was assessed using a variance inflation factor (VIF) threshold greater than three (Neter, Wasserman, & Kutner, 1989). In the first step, baseline cardiovascular reactivity scores (i.e. SBP, DBP, and HR) were entered, followed by anxiety (VAS-A), relaxation, (VAS-R), and affect (PANAS- N, P) in the second step.

The only significant predictors of baseline pain threshold were anxiety (VAS-A; $\beta$ = -.37, $p$ < .05) and relaxation (VAS-R; $\beta$ = -.37, $p$ < .05), indicating increases in both anxiety and relaxation had a negative effect on pain threshold. Pain tolerance was assessed using the same sets of predictors. Relaxation was a statistically significant predictor of pain tolerance ($\beta$ = -.41, $p$ < .01), indicating that increased feelings of relaxation were associated with shorter pain tolerance times. Anxiety (VAS-A; $\beta$ = .34, $p$ .05) and relaxation (VAS-R; $\beta$ = -.37, $p$ < .01) were statistically significant predictors of self-reported pain intensity. The results for pain unpleasantness indicated relaxation was statistically significantly related to decreases in self-reported pain unpleasantness, (VAS-R; $\beta$ = -.30, $p$ < .05). There were no other significant predictors in the models. One-way

ANOVAs indicated there were no statistically significant differences among groups at baseline or intervention on anxiety (VAS-A, VAS-R, STICSA-C, STICSA-S) or mood (PANAS-P, PANAS-N, VAS-E), *p*s > 0.05, *Table 4.5.*

To explore other potential relationships between music exposure and responsiveness to the intervention conditions, the number of years a participant had played a musical instrument and the average hours per week she listened to music were entered into a correlation with intervention pain outcomes (threshold, tolerance, intensity, unpleasantness) and other potential mechanisms (mood, anxiety, relaxation, distraction, control, absorption). There were no statistically significant correlations for either music training or music listening and pain outcomes or other potential mechanisms in the M + S group. In the M group, perceived control ($r$ = - .53, $p$ < .05) and positive affect (PANAS-P, $r$ = .44, $p$ < .05) were significantly associated with number of hours per week the participant reported listening to music.

Table 4.5. *Baseline Anxiety and Emotion across Groups*

| | Baseline Trial | | | Intervention Trial | | |
|---|---|---|---|---|---|---|
| | M + S | M | NT | M + S | M | NT |
| Outcome | M (*SD*) | M (*SD*) | M (*SD*) | M (*SD*) | M (*SD*) | M (*SD*) |
| STICSA Trait | | | | | | |
| Cognitive | 21.0 *(5.2)* | 19.9 *(6.4)* | 18.9 *(6.7)* | | | |
| Somatic | 15.9 *(2.8)* | 16.4 *(4.9)* | 16.7 *(4.7)* | | | |
| STICSA State | | | | | | |
| Cognitive | 17.9 *(6.8)* | 16.5 *(6.5)* | 15.6 *(6.7)* | 15.0 (*4.7*) | 14.0 (*6.2*) | 15.2 (*7.1*) |
| Somatic | 17.9 *(4.6)* | 17.7 *(6.3)* | 16.9 *(4.9)* | 15.3 (*4.3*) | 15.2 (*3.3*) | 17.1 (*5.7*) |
| VAS-A | 3.5 (*2.5*) | 3.2 (*2.6*) | 3.6 (*2.1*) | 2.5 (*1.9*) | 2.8 (*2.5*) | 3.2 (*2.4*) |
| VAS-R | 4.5 (*2.6*) | 5.3 (*2.5*) | 4.9 (*1.6*) | 5.6 (*2.3*) | 4.9 (*2.2*) | 5.3 (*2.6*) |
| PANAS-P | 22.7 *(6.7)* | 23.0 *(6.9)* | 20.1 *(7.1)* | 21.0 (*6.5*) | 21.0 (*7.3*) | 18.2 (*6.8*) |
| PANAS-N | 14.9 *(4.3)* | 14.1 *(4.4)* | 14.3 *(3.8)* | 12.3 (*2.3*) | 13.2 (*3.4*) | 14.3 (*4.3*) |
| VAS-E | 1.5 *(1.8)* | 1.5 *(1.6)* | 1.3 *(1.6)* | 1.0 (*1.3*) | 1.7 (*1.9*) | 2.1 (*2.2*) |

*Note*: State Trait Inventory for Cognitive and Somatic Anxiety (STICSA); Visual Analog Scale for Anxiety (VAS-A); Visual Analog Scale for Relaxation (VAS-R); Positive and Negative Affect Scale (PANAS); Visual Analog Scale for Emotional Distress (VAS-E).

# CHAPTER FIVE

## Discussion

The purpose of this study was to assess the effects of M + S on experimental pain and explore variables that may contribute to the observed effects. It was hypothesized that music combined with suggestions (M + S) would decrease experimental pain compare to music (M) and that M would decrease experimental pain more than no treatment (NT). M + S and M did not demonstrate statistically significant improvements in pain threshold, pain intensity, or pain unpleasantness, compared to NT. However, M was statistically significantly better than NT for increasing pain tolerance. The results of correlation analyses indicate treatment expectancy and distraction explained part of the observed effect of M on pain tolerance. This is consistent with previous literature that reports music listening is associated with increased levels of distraction and improvements in cold pressor pain tolerance (Finlay & Anil, 2016; Silvestrini, Piguet, Cedraschi, & Zentner, 2011). Surprisingly, in this study, treatment expectancy (i.e., "Based on the intervention you will receive, on the next trial, how much pain do you expect to feel?"), had an inverse relationship with pain tolerance in the M condition, indicating a higher level of treatment expectancy was related to decreased pain tolerance.

In contrast to the stated hypotheses, hypnotizability was not shown to be significantly related to pain reductions in the M + S group. It is possible that this finding is partially due to the low number of participants that were in the "High" category of hypnotizability. Hypnotizability and absorption demonstrated a statistically significant

positive relationship in the M + S intervention group, but not in the M or NT groups. This implies that the more hypnotizable a person is the more absorbed they became in the M + S intervention. It is possible that M + S may work through similar pathways as hypnosis to reduce pain. It is likely this effect was not observed in the current study due to the small sample of highly hypnotizable participants in the M + S condition. In addition, if M + S does in fact function as a type of hypnotic analgesia, the choice of suggestions could influence the effects of the intervention. For example, in this study, the suggestions were predominantly focused on relaxation and comfort. It has been shown that analgesic-focused suggestions are more beneficial for experimental pain than relaxation-focused suggestions (Hilgard, 1978).

Pain is a salient event. The use of cognitive strategies, such as music or music combined with suggestion, to reduce pain may rely on the ability the intervention to distract a person from the pain experience. It is possible that M and M + S were of insufficient to direct attention away from the painful stimulus (Finlay, 2014). This may be due in part to the use of researcher-selected music. It is possible that participant-selected music may be a more sufficient distractor and attenuate nociceptive processing (Hekmat & Hertel, 1993).

It was also hypothesized that the M + S group would show less cardiovascular responding than M or NT to cold pressor pain. This hypothesis was not supported in the current study. Past research has also demonstrated a lack of cardiovascular responding to music interventions even though patients report less pain unpleasantness in response to cold pressor pain (Garcia & Hand, 2016). A review of cardiovascular responses across groups indicates that all groups (e.g., M, M + S, NT) showed lower cardiovascular

reactivity in the intervention trial than in the baseline trial. This indicates that cardiovascular indices may not have completely returned to baseline levels prior to the intervention trial, despite the non-significant differences in BP and HR measures between baseline and intervention rest periods. It is possible that a longer recovery time (e.g. > 15 minutes) may be needed when using water temperatures of 1°C. It is possible that participants in the NT condition were engaged in self-chosen cognitive coping strategies.

Baseline pain outcomes were statistically significantly related to anxiety and relaxation. This is consistent with the biopsychosocial model of pain that asserts the pain experience consists of affective factors as well as biological and social (Gatchel et al., 2007). There were no statistically significant differences among groups on anxiety, relaxation, or mood measures (e.g., BP, HR, VAS-A, VAS-R, STICSA, and PANAS) during the intervention trials. This may explain in part why M and M + S did not demonstrate significant improvements in experimental pain over the NT group. As stated previously, it is possible that participants in the NT condition also experienced relaxation as a function of their own self-chosen cognitive strategy during the intervention trial. It is also possible that there was a floor effect in the current study due to screening procedures (e.g. PHQ-4). Participants with higher levels of baseline anxiety may have reacted more positively to interventions designed to induce relaxation (e.g., M + S).

### *Limitations*

Several limitations have already been noted. Further limitations include the use of experimental pain to determine the effects of an arts-based psychosocial intervention for clinical pain. Experimental pain is limited in its generalizability to clinical pain. Experimental pain procedures do not readily replicate the inflammatory responses and

deep structural changes that are common to clinical pain (Petersen-Felix & Arendt-Nielsen, 2002). In addition, the transient nature of the pain and the ability of the participant to stop the pain (e.g. control) in the experimental paradigm, changes the meaning and salience of the experience. Experimental pain cannot fully replicate the experiential affective and sensory components of clinical pain (Gracely, 1991). However, experimental pain studies do allow for important contributions to better understanding pain measurement and group differences (Edwards et al., 2005).

Another limitation of this study was the use of a no-treatment control group. In this group, cognitive attention in the control group was left largely 'undirected'. It is not known if participants in the control group were spontaneously using other forms of distraction or what their attention was focused on. It is possible that participants were engaged in mediation, prayer, mindfulness, or other forms of cognitive processing. The average pain tolerance in the NT group did increase. This is inconsistent with previous research and points to the possibility that participants were engaging in some form of cognitive strategy that enabled an increased pain tolerance. For example, in a study of the pain relieving effects of preferred music, participants who did not receive any intervention (i.e. control) showed decreased pain tolerance and increased pain intensity on a second cold pressor trial, though not statistically significant (Hekmat & Hertel, 1993). It is possible that the noise cancelling headphones used in this study facilitated the use of participant-chosen coping strategies in the NT group. The increase in pain threshold and pain tolerance for all groups seems to indicate either a conditioning effect or that the NT groups was actually engaging in some type of coping strategy whereby they were able to distract themselves from pain.

In addition, the use of experimenter-selected music could have influenced the effectiveness of the intervention. The music selected for this study has been used successfully in previous research investigating the pain relieving effects of music (Crowe, 2004). However, past research suggests that participant-selected music may be more effective in reducing pain intensity and increasing pain tolerance and feelings of control (Hekmat & Hertel, 1993; Mitchell & MacDonald, 2006). It is possible that music may be more effective for pain when the music is more liked by the listener (Wright & Raudenbush, 2010).

Another aspect to consider is the use of relaxation suggestions. In a previous study employing similar suggestions, participants with serious illness and chronic pain experienced clinically meaningful reductions in pain bothersomeness (Johnson et al., 2017). However, relaxation suggestions may not be as effective in acute, procedural-type pain. Acute pain may respond better to analgesic suggestions that focus on pain reduction and changes in sensation instead of comfort and relaxation. It is also possible that the suggestions used in this study were less effective due to their brevity and delivery method. It is possible that suggestions delivered 'in-person' may be more effective due to social-cognitive influences. In addition, it is possible that a longer suggestion script could be more effective.

While several studies have demonstrated the differential responding of males and females to cold pressor pain (Fillingim, King, Ribeiro-Dasilva, Rahim-Williams, & Riley, 2009; Fillingim & Ness, 2000; Mitchell & MacDonald, 2006), and restricting participation to females only controlled for these gender differences in pain tolerance, important information could be gained by including males in the sample. Including both

genders would provide a more representative sample of the population and would provide valuable insight into any possible differences between male and female coping strategies (Fillingim et al., 2009; Keogh & Herdenfeldt, 2002). For example, in a study comparing the effects of preferred to relaxing music listening on cold pressor pain, there was a significant interaction of gender and listening condition (Mitchell & MacDonald, 2006). Further, research indicates males may find attention-focused interventions to be more effective for pain, and females prefer emotion-focused interventions (Keogh & Herdenfeldt, 2002). Understanding these differences would inform science regarding who could potentially benefit the most from psychosocial arts-based interventions such as music and suggestion.

### *Future Directions*

This study provides additional support for the use of music and suggestion for pain relief. Future research investigating these effects would benefit from the use of male and female participants. In addition, the use of highly hypnotizable subjects would provide a better understanding of the possible benefits of a combined music and suggestion intervention for pain and help to elucidate persons that may be more responsive to this type of treatment. More studies are needed to better understand what factors are being influenced by music and music and suggestions. Future studies including semi-structured qualitative interviews would be beneficial for better understanding what, if any, cognitive strategies are being employed in various interventions (e.g., NT, M, M + S). In addition, offering participants a limited selection of music may improve the effects of the interventions. Testing of this hypothesis is

warranted given the current interest in music as an adjunctive treatment for procedural, acute and chronic pain.

It is possible that music combined with suggestions could become more effective with practice, much like self-hypnosis or meditation. That as one "learned" to use the music, it could become more beneficial. Future studies should include interventions (M and M + S) that are sustained over longer periods of time and are standardized. These types of studies would allow for the assessment of the specific components that may increase the potential benefits of music for pain.

It is recognized that different types of suggestions may be more appropriate for various types of pain. Future studies using suggestions designed for specific types of pain are warranted. It is possible too that the delivery method of music and suggestion may influence its effectiveness. Studies comparing the effects of music and suggestion through self-delivery and 'professional'-delivery may help to better understand the social-cognitive effects underlying the intervention.

Objective (e.g. threshold and tolerance), and subjective (e.g., intensity and unpleasantness) measures of pain may represent two unique factors of a higher-order experimental pain construct. All pain outcome variables within each intervention group were assessed for potential relationships. Pain threshold and pain tolerance were positively related as were pain intensity and pain unpleasantness in both groups. There were no statistically significant correlations between the objective (e.g. threshold and tolerance), and subjective (e.g. intensity and unpleasantness) indicators of experimental pain. The high positive correlations among indicators of self-rated pain suggest that subjectively rated pain intensity and pain unpleasantness during a cold pressor trial may

not be distinct conceptualizations among participants. The lack of relationship between self-reported pain and objectively measured pain indicates two distinct factors are being measured. The current sample was too small to effectively assess the feasibility of a higher order pain construct. Future studies utilizing large samples are warranted to better understand the measurement of experimental pain.

### *Conclusions*

While the findings from this study did not support the hypotheses, pain tolerance did increase in the M group compared to M + S and NT. Distraction and treatment expectancy may explain part of this effect. Baseline pain outcomes were predicted by self-reported anxiety and relaxation in the total sample. Music is a safe, easy to use, low cost adjunct to pain management. It is possible that the addition of suggestions could improve its effectiveness. Future studies utilizing different types of suggestions, highly hypnotizable participants, participant-selected music, and various pain outcomes will assist our understanding of what underlies the effects of music and suggestion on pain. More investigations are warranted for both music and music combined with suggestions in order to understand their potential as adjunctive pain interventions.

# APPENDICES

# APPENDIX A

## Suggestion Script

Hello. My name is Alisa Johnson. This recording is designed to introduce you to music listening for pain reduction.

As you listen to this recording, you can continue to sit comfortably and know that you are in a safe and calm place... where you can relax with your eyes closed.

As you begin to relax... maybe your head is resting on the back of the chair...maybe your eyes have become very heavy...and maybe you will allow your eyes to close so that you can better concentrate on your thoughts as the music plays...knowing that there is nothing you need to try to do... and nothing you need to think about.

Now, with your eyes closed, you may begin to notice your breathing. As you breathe out, you may feel tension dissipate into the atmosphere...As you breathe out each time, you may feel yourself relax more ...and more.

As you listen to this recording, it will be possible to become more and more relaxed. As the music plays, it will be possible to become more and more comfortable...

As you listen to the recording and focus on the music...you will hear the tone of the music rise and fall... you can let your mind move with the music...becoming so absorbed in the music that everything else fades into the background...

As you listen and follow the lead of the music, you may notice changes in sensation...perhaps a heavy feeling, or a floating feeling, or an analgesic feeling...or... you

may not notice any sensations at all... in fact, you may not feel anything at all while the music is playing.

As you become so absorbed in the music... it may bring to your mind thoughts and images that are calm, relaxing ...soothing...and pleasant

Later, when I tap you on the shoulder... as you place your hand in the water... it may seem like your hand is just floating...comfortably...as you listen to the music... you may be so absorbed in the music that you are not even aware of the water...

As you continue to listen to the music...your hand may feel heavy...or numb... or you may not notice it at all...

As you listen to the music...you are comfortable and relaxed and safe...knowing that you can let your hand rest in the water as long as you wish...

Now... listen and relax...

Listen and become so absorbed in the music that everything else drifts into the background.

# APPENDIX B

## Extended Tables

Table B.1 *Sample Characteristics*

| | Total | | M+S | | M | | NT | |
|---|---|---|---|---|---|---|---|---|
| Variable | N | % | N | % | N | % | N | % |
| Age, *M(SD)* | | | *19.5 (1.99)* | | *19.57(.9)* | | | |
| Family Income | | | | | | | | |
| < $15,000 | 1 | 1.6 | 1 | 4.8 | 0 | 0 | 0 | 0 |
| $15,000 – 34,999 | 2 | 3.2 | 1 | 4.8 | 0 | 0 | 1 | 4.8 |
| $35,000 – 49,999 | 7 | 11.1 | 2 | 9.5 | 2 | 9.5 | 3 | 14.3 |
| $50,000 – 74,999 | 13 | 20.6 | 3 | 14.3 | 4 | 19 | 6 | 28.6 |
| $75,000 or more | 40 | 63.4 | 14 | 66.7 | 15 | 71.4 | 11 | 52.4 |
| Parent's difficulty paying for basics | | | | | | | | |
| No difficulty | 51 | 80.9 | 17 | 81 | 19 | 90.5 | 15 | 71.4 |
| Some difficulty | 11 | 17.5 | 4 | 19 | 2 | 9.5 | 5 | 23.8 |
| A lot of difficulty | 1 | 1.6 | 0 | 0 | 0 | 0 | 1 | 4.8 |
| Parent's Education | | | | | | | | |
| < High school | 1 | 1.6 | 0 | 0 | 1 | 4.8 | 0 | 0 |
| High school/ GED | 7 | 11.1 | 2 | 9.5 | 3 | 14.3 | 2 | 9.5 |
| Some college | 5 | 7.9 | 1 | 4.8 | 1 | 4.8 | 3 | 14.3 |
| Associate degree | 1 | 1.6 | 0 | 0 | 0 | 0 | 1 | 4.8 |
| Bachelor's degree | 23 | 36.5 | 9 | 42.9 | 8 | 38.1 | 6 | 28.6 |
| Master's degree | 16 | 25.4 | 5 | 23.8 | 5 | 23.8 | 6 | 28.6 |
| Doctorate degree | 10 | 15.9 | 4 | 19 | 3 | 14.3 | 3 | 14.3 |
| Ethnicity | | | | | | | | |
| Hispanic, Latina, or Spanish | 13 | 20.6 | 4 | 19 | 3 | 14.3 | 6 | 28.6 |
| Non-Hispanic, Latina or Spanish | 50 | 79.4 | 17 | 81 | 18 | 85.7 | 15 | 71.4 |
| Race | | | | | | | | |
| American Indian/ Alaskan Native | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Asian | 10 | 15.9 | 4 | 19 | 2 | 9.5 | 4 | 19 |
| Black/African American | 5 | 7.9 | 3 | 14.3 | 2 | 9.5 | 0 | 0 |
| Native Hawaiian/ Pacific Islander | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| White/Caucasian | 45 | 71.4 | 14 | 66.7 | 16 | 76.2 | 15 | 71.4 |
| More than one race/Other | 3 | 4.8 | 0 | 0 | 1 | 4.8 | 2 | 9.5 |

(continued)

| Variable | Total | | M+S | | M | | NT | |
|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % |
| Sleep | | | | | | | 6.45*(1.9)* | |
| Hours, *M(SD)* | 7 (*1.5)* | | 7.14 *(1.1)* | | 7.4*(1.4)* | | | |
| Quality, *M(SD)* | 7.3 (*1.8*) | | 7.7 *(1.5)* | | 7.14*(1.3)* | | 7.09*(2.4)* | |
| Exercise | | | | | | | | |
| Yes | 54 | 85.7 | 18 | 85.7 | 18 | 85.7 | 18 | 85.7 |
| No | 9 | 14.3 | 3 | 14.3 | 3 | 14.3 | 3 | 14.3 |

Table B.2. *Missing Data, (N = 63)*

| Variable | #Missing | % |
|---|---|---|
| *Age | 1 | 0.01 |
| Family Income | 0 | 0.00 |
| Hispanic | 0 | 0.00 |
| Difficulty paying for necessities | 0 | 0.00 |
| Education | 0 | 0.00 |
| Race | 0 | 0.00 |
| Sleep (hrs.) | 0 | 0.00 |
| Sleep (quality) | 0 | 0.00 |
| Exercise (y/n) | 0 | 0.00 |
| If yes, how many days | 0 | 0.00 |
| If yes, how many min. | 0 | 0.00 |
| Dominant hand | 0 | 0.00 |
| Do you play a musical instrument? (y/n) | 1 | 0.01 |
| What instrument? | 1 | 0.01 |
| What instrument? (2) | 1 | 0.01 |
| For how many years | 1 | 0.01 |
| Do you still play? (y/n) | 1 | 0.01 |
| If yes, what instrument? | 1 | 0.01 |
| Have you ever received musical training? (y/n) | 1 | 0.01 |
| If yes, how many years? | 1 | 0.01 |
| *How often do you listen to music? | 3 | 0.02 |
| Favorite genre (1) | 1 | 0.01 |
| Favorite genre (2) | 1 | 0.01 |
| Favorite genre (3) | 1 | 0.01 |
| When do you listen? | 1 | 0.01 |
| STICSA_T1 | 0 | 0.00 |
| STICSA_T2 | 0 | 0.00 |
| *STICSA_T3 | 1 | 0.01 |

(continued)

| Variable | #Missing | % |
|---|---|---|
| *STICSA_T4 | 1 | 0.01 |
| STICSA_T5 | 0 | 0.00 |
| STICSA_T6 | 0 | 0.00 |
| STICSA_T7 | 0 | 0.00 |
| STICSA_T8 | 0 | 0.00 |
| STICSA_T9 | 0 | 0.00 |
| STICSA_T10 | 0 | 0.00 |
| STICSA_T11 | 0 | 0.00 |
| STICSA_T12 | 0 | 0.00 |
| STICSA_T13 | 0 | 0.00 |
| STICSA_T14 | 0 | 0.00 |
| STICSA_T15 | 0 | 0.00 |
| STICSA_T16 | 0 | 0.00 |
| STICSA_T17 | 0 | 0.00 |
| STICSA_T18 | 0 | 0.00 |
| STICSA_T19 | 0 | 0.00 |
| *STICSA_T20 | 1 | 0.01 |
| STICSA_T21 | 0 | 0.00 |
| PI_prebaseline | 1 | 0.01 |
| PU_prebaseline | 1 | 0.01 |
| A_prebaseline | 1 | 0.01 |
| R_prebaseline | 1 | 0.01 |
| PI_baseline | 0 | 0.00 |
| PU_baseline | 0 | 0.00 |
| A_baseline | 0 | 0.00 |
| R_baseline | 0 | 0.00 |
| PANAS_1_B | 0 | 0.00 |
| PANAS_2_B | 0 | 0.00 |
| PANAS_3_B | 0 | 0.00 |
| PANAS_4_B | 0 | 0.00 |
| PANAS_5_B | 0 | 0.00 |
| PANAS_6_B | 0 | 0.00 |
| PANAS_7_B | 0 | 0.00 |
| PANAS_8_B | 0 | 0.00 |
| PANAS_9_B | 0 | 0.00 |
| PANAS_10_B | 0 | 0.00 |
| PANAS_11_B | 0 | 0.00 |
| PANAS_12_B | 0 | 0.00 |
| PANAS_13_B | 0 | 0.00 |
| PANAS_14_B | 0 | 0.00 |
| PANAS_15_B | 0 | 0.00 |

(continued)

| Variable | #Missing | % |
|---|---|---|
| PANAS_16_B | 0 | 0.00 |
| PANAS_17_B | 0 | 0.00 |
| PANAS_18_B | 0 | 0.00 |
| PANAS_19_B | 0 | 0.00 |
| PANAS_20_B | 0 | 0.00 |
| PANAS_TOTAL_B | 0 | 0.00 |
| EM_baseline | 0 | 0.00 |
| *STICSA_S_1_B | 1 | 0.01 |
| *STICSA_S_2_B | 1 | 0.01 |
| *STICSA_S_3_B | 1 | 0.01 |
| *STICSA_S_4_B | 2 | 0.01 |
| *STICSA_S_5_B | 1 | 0.01 |
| *STICSA_S_6_B | 1 | 0.01 |
| *STICSA_S_7_B | 1 | 0.01 |
| *STICSA_S_8_B | 1 | 0.01 |
| *STICSA_S_9_B | 1 | 0.01 |
| *STICSA_S_10_B | 1 | 0.01 |
| *STICSA_S_11_B | 1 | 0.01 |
| *STICSA_S_12_B | 1 | 0.01 |
| *STICSA_S_13_B | 1 | 0.01 |
| *STICSA_S_14_B | 2 | 0.01 |
| *STICSA_S_15_B | 1 | 0.01 |
| *STICSA_S_16_B | 1 | 0.01 |
| *STICSA_S_17_B | 1 | 0.01 |
| *STICSA_S_18_B | 1 | 0.01 |
| *STICSA_S_19_B | 2 | 0.01 |
| *STICSA_S_20_B | 1 | 0.01 |
| *STICSA_S_21_B | 1 | 0.01 |
| *Expectancy | 1 | 0.01 |
| *Treatment_Exp | 1 | 0.01 |
| *PI_preintervention | 2 | 0.01 |
| *PU_preintervention | 2 | 0.01 |
| *A_preintervention | 2 | 0.01 |
| *R_preintervention | 2 | 0.01 |
| *EHS | 3 | 0.02 |
| PI_intervention | 0 | 0.00 |
| PU_intervention | 0 | 0.00 |
| A_intervention | 0 | 0.00 |
| R_intervention | 0 | 0.00 |
| PANAS_1_E | 0 | 0.00 |
| *PANAS_2_E | 1 | 0.01 |

(continued)

| Variable | #Missing | % |
|---|---|---|
| PANAS_3_E | 0 | 0.00 |
| PANAS_4_E | 0 | 0.00 |
| PANAS_5_E | 0 | 0.00 |
| PANAS_6_E | 0 | 0.00 |
| PANAS_7_E | 0 | 0.00 |
| PANAS_8_E | 0 | 0.00 |
| PANAS_9_E | 0 | 0.00 |
| PANAS_10_E | 0 | 0.00 |
| PANAS_11_E | 0 | 0.00 |
| PANAS_12_E | 0 | 0.00 |
| PANAS_13_E | 0 | 0.00 |
| PANAS_14_E | 0 | 0.00 |
| PANAS_15_E | 0 | 0.00 |
| PANAS_16_E | 0 | 0.00 |
| PANAS_17_E | 0 | 0.00 |
| PANAS_18_E | 0 | 0.00 |
| PANAS_19_E | 0 | 0.00 |
| PANAS_20_E | 0 | 0.00 |
| EM_intervention | 0 | 0.00 |
| Control_VAS | 0 | 0.00 |
| Distracted_VAS | 0 | 0.00 |
| Absorbed_VAS | 0 | 0.00 |
| STICSA_S_1_E | 0 | 0.00 |
| STICSA_S_2_E | 0 | 0.00 |
| STICSA_S_3_E | 0 | 0.00 |
| STICSA_S_4_E | 0 | 0.00 |
| STICSA_S_5_E | 0 | 0.00 |
| STICSA_S_6_E | 0 | 0.00 |
| STICSA_S_7_E | 0 | 0.00 |
| STICSA_S_8_E | 0 | 0.00 |
| STICSA_S_9_E | 0 | 0.00 |
| STICSA_S_10_E | 0 | 0.00 |
| STICSA_S_11_E | 0 | 0.00 |
| STICSA_S_12_E | 0 | 0.00 |
| STICSA_S_13_E | 0 | 0.00 |
| STICSA_S_14_E | 0 | 0.00 |
| STICSA_S_15_E | 0 | 0.00 |
| STICSA_S_16_E | 0 | 0.00 |
| STICSA_S_17_E | 0 | 0.00 |
| STICSA_S_18_E | 0 | 0.00 |
| STICSA_S_19_E | 0 | 0.00 |

(continued)

| Variable | #Missing | % |
|---|---|---|
| STICSA_S_20_E | 0 | 0.00 |
| STICSA_S_21_E | 0 | 0.00 |
| *PB_SBP_15sec | 1 | 0.01 |
| *PB_DBP_15sec | 1 | 0.01 |
| HR_15sec | 0 | 0.00 |
| *PB_SBP_105sec | 4 | 0.03 |
| *PB_DBP_105sec | 4 | 0.03 |
| HR_105sec | 0 | 0.00 |
| PB_SBP_195sec | 4 | 0.03 |
| *PB_DBP_195sec | 4 | 0.03 |
| HR_195sec | 0 | 0.00 |
| PB_SBP_285sec | 0 | 0.00 |
| PB_DBP_285sec | 0 | 0.00 |
| HR_285sec | 0 | 0.00 |
| PB_SBP_600sec | 0 | 0.00 |
| PB_DBP_600sec | 0 | 0.00 |
| HR_600sec | 0 | 0.00 |
| *PB_SBP_900sec | 4 | 0.03 |
| *PB_DBP_900sec | 4 | 0.03 |
| HR_900sec | 0 | 0.00 |
| *PB_SBP_990sec | 2 | 0.01 |
| *PB_DBP_990sec | 2 | 0.01 |
| HR_990sec | 0 | 0.00 |
| *PB_SBP_1080sec | 2 | 0.01 |
| *PB_DBP_1080sec | 2 | 0.01 |
| HR_1080sec | 0 | 0.00 |
| PB_SBP_1170sec | 0 | 0.00 |
| PB_DBP_1170sec | 0 | 0.00 |
| HR_1170sec | 0 | 0.00 |
| Baseline_handtemp | 0 | 0.00 |
| *B_SBP_5sec | 5 | 0.04 |
| *B_DBP_5 | 5 | 0.04 |
| *B_HR_5 | 4 | 0.03 |
| B_SBP_40sec | 52 | 0.37 |
| B_DBP_40 | 52 | 0.37 |
| B_HR_40 | 52 | 0.37 |
| *B_SBP_withdrawal | 3 | 0.02 |
| *B_DBP_withdrawal | 3 | 0.02 |
| *B_HR_withdrawal | 3 | 0.02 |
| PreInt_SBP_600sec | 0 | 0.00 |
| PreInt_DBP_600sec | 0 | 0.00 |

(continued)

| Variable | #Missing | % |
|---|---|---|
| *PreInt_HR_600sec | 1 | 0.01 |
| PreInt_SBP_900sec | 0 | 0.00 |
| PreInt_DBP_900sec | 0 | 0.00 |
| PreInt_HR_900sec | 0 | 0.00 |
| *PreInt_SBP_1080sec | 4 | 0.03 |
| *PreInt_DBP_1080 | 4 | 0.03 |
| *PreInt_HR_1080 | 4 | 0.03 |
| *PreInt_SBP_1170sec | 2 | 0.01 |
| *PreInt_DBP_1170 | 2 | 0.01 |
| PreInt_HR_1170 | 0 | 0.00 |
| *Int_SBP_5sec | 14 | 0.10 |
| *Int_DBP_5sec | 14 | 0.10 |
| *Int_HR_5sec | 0 | 0.00 |
| Int_SBP_40sec | 45 | 0.32 |
| Int_DBP_40sec | 45 | 0.32 |
| Int_HR_40 | 45 | 0.32 |
| *Int_SBP_withdrawal | 6 | 0.04 |
| *Int_DBP_withdrawal | 6 | 0.04 |
| *Int_HR_withdrawal | 0 | 0.00 |
| *B_threshold | 2 | 0.01 |
| B_tolerance | 0 | 0.00 |
| *I_threshold | 3 | 0.02 |
| I_tolerance | 0 | 0.00 |

*Note.* * missing values imputed

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