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The Efficacy of Music as a Non-Analgesic Method of Reducing Pain Perception during Cold Pressor Trials

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THE EFFICACY OF MUSIC AS A NON-ANALGESIC METHOD OF REDUCING PAIN PERCEPTION DURING COLD PRESSOR TRIALS

by
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The purpose of this project was to investigate the impact of differentiated onset of self-selected music on pain perception and pain tolerance during a cold pressor test. Subjects participated in four trials during which music was presented at different points of time in relation to their exposure to the cold pressor test. Results indicated that listening to music prior to and concurrently with the onset of the pain resulted in lower self-reported pain ($F(3, 66) = 3.25$, $p < .05$). Behavioral results indicated that subjects were able to tolerate an average of 25s longer ($F(2.04, 44.81) = 1.56$, $p > .05$.) when music was presented after the onset of painful stimuli. Both results have positive implications for the clinical use of music as a non-pharmalogic analgesic method of reducing pain perception and increasing pain tolerance. The onset of music as a pain mediation stimulus may be differentially indicated based on the nature of the procedure. Future research could examine the amount of pre-procedure time indicated to be most effective toward pain perception and tolerance. It is currently unknown if a longer induction period would differentially impact any of the outcome measures and if listening to a song in its entirety prior to exposure to adverse stimuli would have an impact on the outcome measures. Following controlled laboratory studies, translational research would be required to examine clinical efficacy.

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Amanda Lynn Ziemba

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CHAPTER I

INTRODUCTION

Statement of the problem

The use of nonpharmacological methods of pain management has been the focus of considerable research in the past decade (Mitchell, MacDonald, & Knussen, 2008; MacDonald, Mitchell, Dillon, Serpell, Davies, & Ashley, 2003; Magill, 2001). Research has focused on different types of nonanalgesics and their efficacy in relieving pain, reducing anxiety, increasing pain tolerance or decreasing pain perception (Chi, 2009; Mitchell et al., 2008; Plodder, 2007; Siedliecki & Good, 2006). The use of music has been the focus of numerous studies because of its unique ability to affect both the physiological and emotional components of pain sensation (Gold & Clare, 2012; Roy, Mailhot, Gosselin, Paquette, & Peretz, 2009; Klassen, Liang, Tjosvold, Klassen, & Hartling, 2008; Thaut & Davis, 1989). Research has shown that music has effectively provided pain relief and increased pain tolerance in a variety of situations, within research settings and during clinical care situations (Mitchell, MacDonald, & Knussen, 2008; Clark, Isaacks-Downton, Wells, Redlin-Frazier, Eck, Hepworth, & Chakravarthy, 2006; Good, Anderson, Ahn, Cong, & Stanton-Hicks, 2005; Voss, Good, Yates, Baun, Thompson, & Hertzog, 2004). Though there has been significant research in the area of audioanalgesia, no studies were found that investigated the impact that the time at which the music is presented has on pain perception. If the efficacy of audioanalgesia is impacted by the time during which it is provided, this could impact how healthcare professionals treat their patients and provide information towards the creation of a treatment protocol.

Rationale for research

Though the current body of literature demonstrates the efficacy of music as a method of non-analgesic pain relief, no studies have been found that investigate the onset of the musical stimulus that is provided. This study attempted to identify how the efficacy of preferred music is affected by manipulating the onset of music during exposure to an adverse stimulus. The results provided insight into the effectiveness of audioanalgesia at different times that pain is perceived, helping to identify if preferred music was able to have a more significant impact if provided at a specific time. Identifying when the presentation of audioanalgesia during pain perception was most effective could provide support for health professionals and their treatment of patients.

Research questions

Research Question 1

Will the use of a self-selected piece of music during a cold pressor test positively impact pain perception?

Research Question 2

Will the use of a self-selected piece of music during a cold pressor test increase the duration of time exposed to the adverse stimuli?

Research Question 3

Will a significant difference be found between the different intervals of time at which the music is introduced on the predictors of; perception of pain and duration of time exposed to the adverse stimuli?

Definitions of terms

Analgesia is the, "Absence of or freedom from pain; loss or diminution of the ability to feel pain; diminished perception of painful stimuli". (OED Online, 2014). The term analgesic is defined as, "that relieves or reduces pain; of or relating to the relief of pain". It can also refer to a drug or treatment that is able to relieve or reduce pain. (OED Online, 2014) Non-analgesic methods of pain relief are often non-pharmacological and could be used when medication might not have time to take effect, are inappropriate for the patient, or are unavailable (Mitchell et al., 2008). Non-analgesic methods can involve the use of imagery, relaxation techniques, distraction, and meditation among other methods.

Pain perception, also referred to as nociception, is a very subjective sensation that can be impacted by a variety of factors, including: age, sex, previous experiences, and a person's level of fatigue (Debono, Hoeksema, & Hobbs, 2013; Gold & Clare, 2012; International Association for the Study of Pain, May). The International Association for the Study of Pain defines pain 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, May). Both the physiological and psychological components of nociception are important to consider during the treatment of pain.

Chronic pain is defined as pain that lasts longer than three to six months, a variable period of time that is considered to be much longer than the normal healing period (Committee on Advancing Pain Research, Care, and Education, Institute of Medicine, Board on Health Sciences Policy, 2011). Chronic pain is often a permanent state without improvement being a likely scenario and is often disruptive to the daily lives of suffers causing issues with work, depression, sexual relations, independence, and sleep (Debono et al., 2013; Committee on Advancing Pain Research, Care, and Education, Institute of Medicine, Board on Health Sciences Policy, 2011; Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006).

The use of music as a non-analgesic method of affecting the sensation of pain and its accompanying emotional elements is referred to as audioanalgesia (Mitchell & MacDonald, 2006; Mitchell, MacDonald & Knussen, 2008). Because one of the main mechanisms behind audioanalgesia relies on the emotional engagement of music, other audio-based treatments such as nature sounds or white noise, would not be categorized as an audioanalgesic.

Summary

Pain is a subjective, emotional, and physical experience that can interrupt the daily lives and well being of those suffering from acute or chronic pain. The use of non-analgesic forms of medication could provide options for patients who are unable to use or aren’t receiving benefit from traditional pharmacological options. Music is a non-pharmacological, non-invasive, widely available medium that has effects on both the physiological and cognitive components of pain perception. The use of music as a non-analgesic form of pain relief could provide doctors and other healthcare professionals with more options for treating their patients. Identifying the specific time at which to administer a musical intervention will provide more information for researchers and healthcare professionals to better help their patients.

CHAPTER II

REVIEW OF LITERATURE

Pain

Pain is a subjective sensory and emotional experience that is one of the main reasons for medical consultation and is often the cause of significant disruption in the quality of life of those suffering from pain (Debono, Hoeksema, & Hobbs, 2013; Turk & Dworkin, 2004; Bassols, Bosch, & Baños, 2002). The prevalence of chronic pain in the United States is significant, with an estimated 100 million patients suffering from some form of chronic pain (Debono et al., 2013). Lasting more than three to six months and far outside of the normal healing time, chronic pain can be a permanent condition that has significant effects on the daily lives of affected (Committee on Advancing Pain Research, Care, and Education, Institute of Medicine, Board on Health Sciences Policy, 2011). The cost of treating pain and chronic pain is astronomical, with the estimated annual cost of treating chronic pain between $560 to 635 billion dollars (Committee on Advancing Pain Research, Care, and Education, Institute of Medicine, Board on Health Sciences Policy, 2011). In 2008, the cost of treating pain was $99 billion dollars for federal and state governments (Committee on Advancing Pain Research, Care, and Education, Institute of Medicine, Board on Health Sciences Policy, 2011).

Because of these issues there has been a significant amount of research conducted to find more cost-effective methods of pain control. Many non-analgesic methods have been found and researchers have begun to look more closely at music as an effective method of decreasing pain perception. The implementation of music in a treatment setting can be done without interfering with other concurrent treatments and is a cost effective approach to relieve pain and reduce pain perception. Mitchell, MacDonald, & Knussen stated that music is, "useful both in conjunction with basic treatment and at times when medication is less effective, not desired, or not allowed sufficient time" (p. 162, 2008).

Researchers have been investigating the use of music as method of pain reduction or distraction for a variety of patient diagnoses and medical procedures, including chronic pain, cancer pain, pre and post-op pain, during radiation treatment, and also pain experienced during labor (Allred, Byers, & Sole, 2010; Clark, Isaacks-Downton, Wells, Redlin-Frazier, Eck, Hepworth & Chakravarthy, 2006; Siedliecki & Good, 2006; Good, Anderson, Ahn, Cong, & Stanton-Hicks, 2005; Magill, 2001). Music has long been utilized as a method of decreasing pain perception and discomfort in a variety of settings and in the past ten years, there has been a large body of research dedicated to finding the mechanisms behind why music can be so effective as a non-analgesic.

Gate control theory

It has been suggested that the reason music is able to work effectively as a method of pain reduction because of its ability to have an effect on both the physiological and emotional aspects of pain. In 1965, Melzack & Wall first put forward the gate-control theory of pain as the mechanism in which both cognitive and physiological factors were able to impact pain perception. The gate-control theory suggests that there is a gateway in the dorsal horn of the spinal cord that is able to manage the reception of pain through the opening and closing of a gate mechanism. During the process of pain perception, pain is received though small nerve fibers, which synapse onto projection neurons that send impulses to the brain. Normal somatosensory information, like the touch of another person, is processed through large nerve fibers that also synapse onto the same projection cells. Projection neurons pass their impulses afferently through the spinothalamic tract to the dorsal horn, where inhibitory neurons intercept them.

The gate-control theory suggests that inhibitory cells prevent the projection neuron from passing along their impulses so that the gateway remains closed when there is no input being received from the small and large nerve fibers (Melzack & Wall, 1965). When the large fibers receive normal somatosensory information it stimulates the projection neuron as well as the inhibitory neurons, but the gateway remains closed because the inhibitory neurons are activated. Pain occurs when the small nerve fibers are stimulated without large nerve fibers or when there are more small nerve fibers stimulated than large ones. When this happens, the small nerve fibers inactivate the inhibitory neurons, allowing the projection neuron to pass their information through the spinothalamic tract to the brain, informing it of pain. The severity of pain that is experienced is determined by the total number of fibers that are active and also the ratio of small fibers to large fibers (Melzack & Wall, 1965).

In terms of music, this theory suggests that music would act as a stimulus for a large number of fibers and would be able to interfere with some of the fibers sending the pain stimulus through the gateway. Unfortunately, this theory does not take into account the cognitive aspects of the pain experience and the brain's ability to actively control the perception of pain.

Amygdala and pain perception

The cognitive and emotional components of the pain experience draw away from the theory put forward by Melzack & Wall and instead implicate a more inclusive model of pain perception. In recent years, the function of the amygdala has been closely researched and investigated because of the connection between its role in emotional processing and pain perception. Researchers have contributed a growing body of evidence that suggests that the amygdala is a major component of pain perception because of its sensory processing and emotional stimuli processing roles (Veinante, Yalcin, & Barrot, 2013)

The amygdala is a cluster of about twelve nuclei that are located within the temporal lobe. These nuclei consist of three or four main groupings, depending upon the referenced literature; the superficial, the laterobasal, the central and the medial groups. The central and medial groups are commonly grouped together and referred to as the centromedial group. Each of these sets of nuclei connect afferently and efferently with different brain structures and systems (Simons, Moulton, Linnman, Carpino, Becerra, & Borsook, 2014; Veinante et al., 2013). Some of the areas that the amygdala connects to include: the hypothalamus, dorsomedial thalamus, thalamic reticular nucleus, nuclei of trigeminal and facial nerves, locus coeruleus, and the laterodorsl tegmental nucleus.

The superficial nuclei of the amygdala are primarily involved in olfaction and has a reciprocal relationship with the olfactory cortex. This nuclei is one of the least understood within the structures of the amygdala. The laterobasal complex contains the lateral, laterobasal, basomedial, and basoventral nuclei within its structure. This grouping of nuclei has afferent pathways to the hippocampus, thalamus, and the prefrontal cortext

(Simons et al., 2014). They are connected to associative learning, specifically playing a role in fear conditioning. In addition to associative learning, the laterobasal complex evaluates sensory information that it receives through afferent pathway connections and then integrates that data with cortical association areas. The laterobasal complex is also involved in the synthesis of glutamate, a vital neurotransmitter (Simons et al., 2014).

The central and medial nuclei, which will be referenced as the centromedial nuclei, have also been implicated in fear conditioning. The centromedial complex is composed of the capsular, central, and medial groups. The centromedial nuclei utilize connections to the cerebral cortex to create behavioral responses through connections with the hypothalamus, basal forebrain, and the brain stem. The laterobasal and the centromedial nuclei, specifically the capsular nuclei within the centromedial group, have been identified as playing a role together in the learning and the expression of fear behaviors because of areas of the brain that they have connections with (Brown et al, 2014).

In terms of pain perception, there has been research that has pointed to the lateral and laterobasal nuclei of the laterobasal complex, as well as the centromedial nuclei, as important structures involved in nociception (Brown et al., 2014; Simons et al., 2014). Specifically, the laterobasal nucleus transmits large amounts of information that it receives from the thalamus and cerebral cortex to the centromedial nuclei (Brown et. al, 2014; Neugebauer 2004). The thalamus and cerebral cortex also transmit information directly to the centromedial nuclei but to a much lesser extent.

The centromedial nucleus also receives large amount of nocioceptive information from the spinal cord and the parabracial nucleus. The parabrachial nucleus gathers the nocioceptive information and uses the spinal chord to transmit the sensory information to the medial thalamus, medial hypothalamus, and the centromedial complex (Neugebauer 2004).

The connections between the different amygdala nuclei, the thalamus, cerebal cortex, spinal chord, and parabracial nucleus demonstrate a strong role for the amygdala and pain perception. Because of all of the structures involved in associative learning, nocioception, and behavioral responses, the amygdala provides an emotional value to the sensory information that it receives through each of the different pathways, specifically within the centromedial nuclei. This also has a direct effect on the behavioral and the autonomic responses to nocioceptive information that is received. A painful experience will be given an emotional context and any future similar pain can be perceived as more painful because of the associations made during the initial event.

Regarding the role of the amygdala as a modulator for pain, Veinante, Yalcin, & Barrot (2013) said that the "…anti- and pro-nocioeptive effects [of the amygdala] are dependent on (1) the type of pain (acute, inflammatory, or chronic); (2) the measured parameters (threshold or latency of reflex withdrawal, vocalizations, emotional component); and (3) the emotional state of the subjects (stress, anxiety, fear and expectation)" (p. 5). Previous experiences of pain, previous injuries resulting in chronic pain, and the current affective state of the patient will all play into how they perceive pain and how the amygdala modulates the information received. The centromedial nuclei receive a large amount of nocioceptive information and is also involved in the analgesia process (Veinante et al., 2013). Research has demonstrated the amygdala is able to play a role in the processes that lead to a lessened pain sensation (Veinante et al., 2013). In cases of chronic pain, brain-imaging studies have shown differences in the activity levels of the amygdala in patients with arthritis, irritable bowel syndrome, and mononeuropathy (Veinante et al., 2013).

This model of pain perception involves both the physiological and emotional aspects of pain perception and provides understanding for why previous experiences of pain will effect how a person perceives pain.

Role of emotion and attention on pain perception

In consideration to music, researchers acknowledge that there are both cognitive and emotional features of music. Both of these features can work to create a decrease in pain perception within subjects. The reduction of pain perception effect of attention has been identified by a number of researchers who found that subjects who were focused on attention-based tasks (e.g.: mental arithmetic, visual stimuli, auditory stimuli, and/or tactile stimuli) experienced reduced pain perception (Mitchell, Villemure & Bushnell, 2002; Tracey, Ploghaus, Gati, Clare, Smith, Menon, & Matthews, 2002; Weid & Verbaten, 2001; Miron, Duncan, & Bushnell, 1989) but subjects who attended to the pain, reported an increase in their pain perception (Weich, Ploner, & Tracey, 2008; Robb, 2003; Villemure, Slotnick, & Bushnell, 2003; Bantick, Wise, Ploghaus, Clare, Smith, & Tracey, 2002; Villemure & Bushnell, 2002; Tracey et al., 2002).

Studies on the effects of attention on pain perception have often discussed the important role of emotions on pain perception. Research has showed that emotions can have a positive or negative impact on pain perception, either mitigating it or increasing the perception of pain (Silverstrini, Piguet, Cedraschi, & Zentner, 2011; Roy, Mailhot, Gosselin, Paquette, & Peretz, 2009; Weish et al., 2008; Villemure et al., 2003; Villemure & Bushnell, 2002). Both attention and emotion are able to modulate the perception of pain. Although studies have shown that though they often utilize the same pathways, there are some different neural pathways that differ between the two (Silverstrini et al., 2011; Villemure & Bushnell, 2009; Villemure et al., 2003; Villemure & Bushnell, 2002). The research base in this area has often mentioned that any tasks that are performed by subjects to investigate pain perception tend to manipulate both emotional and attentional states (Villemure & Bushnell, 2009).

Limited capacity model of attention

The limited capacity model of mediated message processing, also referred to as the limited capacity model of attention, is an information-processing model based in cognitive psychology (Lang, 2000). This model states that humans are information processors that utilize mental resources to process information presented to them. The most important feature of this model is that humans have a limited amount of mental resources available to conduct the information processing, leading to some information not being fully processed completely (Robb, 2003; Lang, 2000; Shiffrin, 1988). The messages or information received by an individual go through three sub-processes that the brain is able to engage in simultaneously and continuously: encoding, storage, and retrieval (Lang, 2000).

The encoding process is the first step in assigning the use of mental resources to receive information and this process uses at least one of the five human senses to receive information (Robb, 2003; Lang, 2000). Once one or more of the senses are engaged, both automatic and controlled processes determine the information selected to be encoded. The controlled selections, "reflect the viewer's goals" (Lang, 2000) which allow the information to be moved into short term memory. Automatic processes are unconsciously conducted and are set in motion by the stimulus. Lang (2000) describes the two major types of automatic selection processes as, "…(a) information that is relevant to the goals and needs of the individual, and (b) information that represents change or an unexpected occurrence in the environment" (p.49). The information is then temporarily part of the short-term memory.

Once information passes the encoding process, it is then engaged in the storage process which links the new information to older information previously stored in the brain. One model of memory, the general associative network model of memory, is utilized in the limited capacity model of mediate message processing. This memory model views, "…individual memories as being connected to other related memories by associations (or links)" (Lang, 2000, p. 49). The information newly encoded then begins to form associations with the other older information that the person has stored, leading to this new information being more solidly stored in the memory (Lang, 2000). This leads to the retrieval process, which selects parts of older messages and brings it into the working memory along other associated memories connected to the message being retrieved (Lang, 2000).

This model of information-processing was part of the reason why Mitchell et al. (2008) proposed that music was an effective analgesic. They suggested that a, "…distracting outside task will leave limited mental resources for pain perception" and that music would be able to act as that distracting stimuli (Mitchell et al., 2008, p. 162).

They also call attention to the associative connections that music has to an individual, which are able to resurface memories and experiences connected to specific musical selections, suggesting that stimuli with emotional connections would serve as a more effective distraction (Mitchell et al., 2008; Robinson, 1998).

Pain and perceived control

Research on the brain structures involved in attention-distraction tasks and pain have implicated the periacqueductal gray (PAG), anterior cingulated cortex (ACC), orbitofrontal cortex, and the posterior parietal cortex in the modulation of pain perception (Villemure & Bushnell, 2009; Weich et al., 2008; Tracey et al., 2002). Weich et al. suggest that expectations of pain are related to the possibility of subsequent pain being rated as high in intensity, than it would have been without that expectation (p. 308, 2009). The authors also describe the reappraisal process, which is thought to address the perceived control that a person may believe they have over a situation in which an adverse stimuli is present (Weish et al., 2008). They stated that, "…perceived control is thought to trigger reappraisal processes that can change the pain experience" (Wiesh et al., 2008).

The concept of appraisals can be separated into primary and secondary appraisals. Sullivan et al. describe primary appraisals as, "…judgments about whether a potential stressor is irrelevant, benign-positive, or stressful" and secondary appraisals as "…beliefs about coping options and their possible effectiveness" (Sullivan, Thorn, Haythronthwaite, Keefe, Martin, Bradley, & Lefebvre, 2001). The two parts of the appraisal process interact to influence the possibility of a coping response (Sullivan et al., 2001; Lazarus &

Folkman, 1984). In addition, the appraisal process is influenced by past experiences. If an individual previously had a negative experience in a certain situation, similar features in a current situation could lead to them appraising the current situation as more stressful then it may be (Robb, 2003).

Along with the appraisal process, a sense of perceived control over pain can also have a significant impact on the emotional and behavioral adjustments. This is especially true in consideration to patients experiencing chronic pain. Research has documented the positive correlation between a patient's perceived sense of control and positive health outcomes (Coughlin, Badura, Fleischer, & Guck, 2000; Skevington, 1995; Wallston & Wallston, 1978). Haythornthwaite and colleagues stated that, "…perceptions of control over pain predict lower levels of pain and disability, few pain behaviors, greater endurance during a physical challenge, and greater physiological wellbeing" (Haythornthwaite, Menefee, Heinberg, & Clark, 1998, p. 34).

The ability to use music at almost any point during a hospitalization makes music a very effective resource for a patient to have and would also encourage a sense of control over a stressful and uncomfortable experience (Mitchell et al., 2008; Clark, Isaacks-Downton, Wells, Redlin-Frazier, Eck, Hepworth, & Chakravarthy, 2006; Mitchell & MacDonald, 2006; Hekmat & Hertel, 1993; Brown, Chen, & Dworkin, 1989).

Music and pain

Music and pain perception

Both the emotional and attentional components of music listening are important in the pain perception process. Knox et al. describe that,

> "…the emotion expressed by a piece of music may be a factor affecting pain in two potential ways: the participant's emotional engagement with music evoking positive pleasant emotions that modify how pain is experienced, and through enhanced efficacy in distracting attention from pain" (Knox, Beveridge, Mitchell, & MacDonald, 2011, p. 1680).

Taking this into consideration, this viewpoint puts more of an emphasis on the subject's relationship with the piece of music rather than the structures contained within the music itself.

The viewpoint that the relationship between a subject and their chosen piece of music doesn't completely negate the possibility that structures within the music play a role in altering pain perception. Knox et al. found that the music selected by their participants, "…predominantly expresses contentment, is generally brighter than other music, and more major in modality" and that, "…the acoustical content and emotion expressed by a piece of music contributed toward the participants emotional engagement with the music and enhances distraction form pain" (p. 1680, 2011). Tempo, melody, beat, and harmony were also found to be important to subjects who were rating their preference of relaxation music (Elliott, Poleman, & McGregor, 2011). In 2011, researchers undertook an analysis of acoustics and mood classification of music that was used for pain-relief (Knox et al., 2011). Their results showed that older participants (mean age being 28.2 and a standard deviation of 11.2) chose, "…music which is of lower intensity, contains less high frequency energy, and with less rapid or complex rhythm patterns" (Knox et al., 2011, p. 1679). Their study also indicated that the mood of the music chose by the participants fell in the "content" mood cluster, which was composed of music that was lower-intensity and slower in tempo (Knox et al., 2011). In their conclusion, they stated that, "Acoustical features are key to determining the emotion expressed by music, and timbral and tonal features are shown to be significantly correlated with measurements of pain tolerance and perceived pain intensity" (Knox et al., 2011, p. 1680)

Self-selected music

The emotional component of the listening process involves the subjective experience of individuals and their associated memories. Music will always evoke a different response from different individuals because of their subjective experiences, moods, and preferences. Pieces of music that have significance to a person will evoke a stronger response than pieces of music that are just considered to be familiar. Self-selected music, "…also to relate to feelings of control over pain, where familiar music can be brought easily into an unfamiliar environment to promote a sense of controllability" (Brown et al. 1989).

Since it is possible for someone to completely control the exact kind of music that they want to listen to at any given time because of the prevalence of personal mp3 players, CDs, and other personal electronics, researchers have suggested that musical choices could be, "used as a very important signifier of important personal information" (Mitchell et al., 2008, p. 163). Because of these important relationships that individuals create with their musical choices, the more connected a person is to the music, the more effective the music will be at decreasing pain perception and providing them with a sense of control. The emotion being expressed in the music can also contribute to the amount of connection to the music that an individual experiences and will impact the effectiveness of the music on pain perception (Knox et al., 2011). In terms of meaning, Aiello indicated that the meaning in a musical piece can be derived from three things, "…(1) intellectual appreciation of the music elements, (2) emotional, aesthetic reaction that results in the appreciation of the stylistic characteristics of the music, and (3) the association of a piece of music with a specific event or place" (Aiello, 1994, p. 56).

The use of subject preferred music as an important factor to consider during research was discussed in 1989 by Davis & Thaut, who implicated preferred music as important to the outcomes of the study, "Assuming the importance of individual attitudes towards the musical stimulus…" (Davis & Thaut, 1989, p. 172). Research compared the use of preferred or self-selected music to non-preferred or researcher-selected music and found that consistently, the preferred music was a more effective stimulus (Lingham & Theorell, 2009; Mitchell et al., 2008; Mitchell & MacDonald, 2006; Hekmat & Hertel, 1993).

Summary

What makes music uniquely capable of being an effective analgesic is its emotional and cognitive features that combine together to impact pain perception. Subject preferred music is able to both focus our attention on an arousal level as well as elicit positive emotions. This allows the music to not only capture their attention, but can also prompt positive associative memories within the subject. This then induces the subject into a positive mood state, which in turn affects the sensory processing of the amygdala. All of these factors interact collectively to reduce the pain perception in the subject during exposure to an adverse stimulus. Music is a low-cost, low-risk, enjoyable, non-pharmacological method of pain control that can be easily implemented in a variety of situations and settings as an adjunct treatment to traditional analgesics. Understanding the most effective time to administer a musical intervention will provide healthcare professionals with more of a clear picture on how to integrate music into the treatment protocol.

CHAPTER III

METHOD

Participants

The subjects in this experiment were recruited using advertisements posted at Western Michigan University in the College of Health and Human Services building, the Bernhard Center Computer lab, a general posting boards located on main campus, as well as in the Dalton School of Music (See Appendix C). Twenty-three male and female subjects were enrolled in the study with an age range of 18-51 years with a mean age of 26 years old (See Tables 1 & 2). To determine the power of the study, the G*Power program (version 3.1.9.2) was used. 28 subjects were needed for the study to be fully powered.

Table 1

Sex of Participants

Sex	Frequency
Female	14
Male	9
Total	23

Table 2

Age of Participants

	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age	23	21.00	51.00	26.73	7.84

Because this study involved the presentation of an adverse stimulus, each subject was screened before participating through the use of a self-report checklist for any preexisting conditions, specifically; heart, circulatory, and blood pressure problems; recent serious injury; chronic pain; diabetes; and/or epilepsy (Appendix A). The presence of one of the preexisting conditions would disqualify a potential subject from participation.

Research design

A repeated measures design was utilized for four trials of cold pressor testing. This design was chosen to test the differences in pain perception and tolerance as a result of time-of-onset of music.

Apparatus

The BioNomadix MP150 data acquisition and analysis system was used to gather the biophysiological data during this experiment. The system utilizes a wireless transponder that attaches at the wrist of the subject with a small Velcro strap for EDA and heart rate data collection. BioNomadix disposable electrodes (model EL-658) were placed on the distal pad of the third and fourth digits of the non-dominant hand with a small amount of electrode conductivity gel and disposable adhesive discs (model ADD 208). They were secured with a small amount of medical tape over the finger and electrode.

The cold pressor test is considered a standardized pain methodology technique that allows for the controlled application of an adverse stimulus and is considered to provide similar level of discomfort as chronic pain (Mitchell et al, 2004; Mitchell & MacDonald, 2006). The cold pressor tests were conducted in a five-gallon plastic bucket filled with 5°C water. The water was monitored for temperature before the start of the experiment and also between each trial with a Taylor® 1488 digital thermometer. Ice was added to lower the temperature of the water if needed to keep it consistently at 5.0°C, plus or minus a maximum of 0.5°C.

Participants provided the researcher verbally or though email with a piece of self-selected music prior to their scheduled meeting time. No restrictions on length or genre were given regarding the piece of music that could be used during the experiment. They were instructed to choose a piece of music that was one of their most preferred, that they found relaxing, or that they used to lessen anxiety. Each participant was told, "Please provide a song that is considered one of your most preferred songs that that you find relaxing, or that you use to lessen anxiety. There is no constraint on genre or length." Headphones were provided and the participant adjusted the volume to a comfortable level by listening to a 5 second clip of their chosen song before the trials began.

Self-Report and Behavioral Measurement indices

The outcome measures included were:

1.) Self-reported pain intensity rating on a 100-mm Visual Analog Scale (VAS) with a range of "no discomfort" to "worst possible discomfort".
2.) Pain tolerance measured by duration of time spent submerged in water.

Procedure

Subjects were instructed to schedule a one-hour block of time for the study and to provide the researcher verbally or through email with the name of their selected piece of music prior to their meeting. Subjects were all instructed that the piece of music, ""Please provide a song that is considered one of your most preferred songs that that you find relaxing, or that you use to lessen anxiety. There is no constraint on genre or length."

Upon arrival, the subjects completed WMU Human Subjects Institutional Review Board consent forms. Participants were then given a short music experience and music listening habits questionnaire (Appendix B). The questionnaire data was collected to investigate any commonalities between music genres, musical training, and the outcome measurements. After finishing the questionnaire, the subjects were seated at a table facing away from the researcher. The researcher was seated at a table out of view, behind the subjects and stayed out of view while the trials were being conducted.

The subjects were then instructed to place the headphones on their head in a comfortable position. A 5 second clip of their self-selected piece of music was played to allow the participants to adjust the volume to a comfortable volume. When they finished their adjustments the subjects then placed their non-dominant hand in a supine position on the table and electrodes were positioned on the distal pad of the third and fourth digits of the non-dominant hand for EDA monitoring (a proxy for autonomic arousal). The subjects were instructed to leave that hand placed in the supine position for the duration of the experiment and to avoid moving it as much as possible.

Each subject participated in the four different trials in a counterbalanced order with a ten-minute break between each of the trials. During the breaks, they filled out the self-reported pain perception measurement indices. A total of three 10-minute breaks occurred and the participants filled out four pain perception indices.

Stimuli were presented at one of four points of onset:

1.) 2 minutes prior to the introduction of the adverse stimuli

2.) Concurrently with the introduction of the adverse stimuli

3.) 30 seconds after the introduction of the adverse stimuli

4.) A control condition where no music was presented

At the onset of each trial, subjects were instructed to submerge their dominant hand in the cold water, when prompted by the researcher, until they felt too uncomfortable to keep it in any longer. The bucket of water was placed at the same height as the chair the participants were seated in, on the same side as their dominant hand. A small pad was placed on the edge of the bucket to provide a comfortable place for the subjects to lean their forearm on while their hand was submerged.

Though subjects were given the choice on when to remove their hand, they were not allowed to keep their hand submerged for over four minutes. This time limit was determined based off of the extant literature as a reference (Mitchell & MacDonald, 2006; Mitchell et al., 2008). At that point, the researcher verbally instructed them to remove their hand and proceed to the next step of the trial. The researcher used a digital stopwatch that was not visible to the subject to record the duration that they kept their hand submerged.

Analysis of the Data

A balanced crossover design was used for each of the measurement indices. A repeated measures analysis of variance (ANOVA) was used to analyze the results. Participants underwent four trials in a counterbalanced order. The dependent variables were pain perception and tolerance time. The biophysiological data collected was not analyzed for the scope of this thesis project.

CHAPTER IV

QUANTITATIVE RESULTS

Visual analog scale: *Self-reported perception of pain*

Mauchly's test indicated that the assumption of sphericity had not been violated, $\chi^2(5) = 4.12$, $p > .05$. Therefore, a repeated measures analysis of variance was conducted. The results show that the self-reported pain perception was significantly affected by the onset of the music, $V = 0.94$, $F(3, 66) = 3.25$, $p < .05$, $w^2 = .03$. (Figure 1).

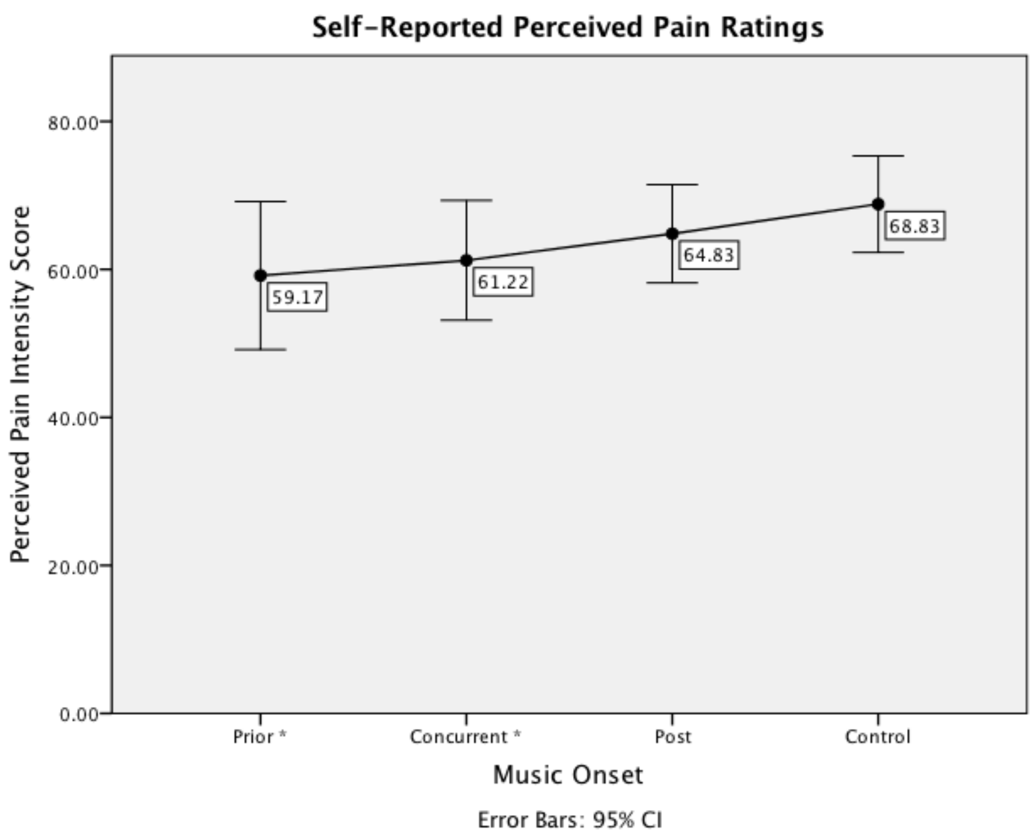
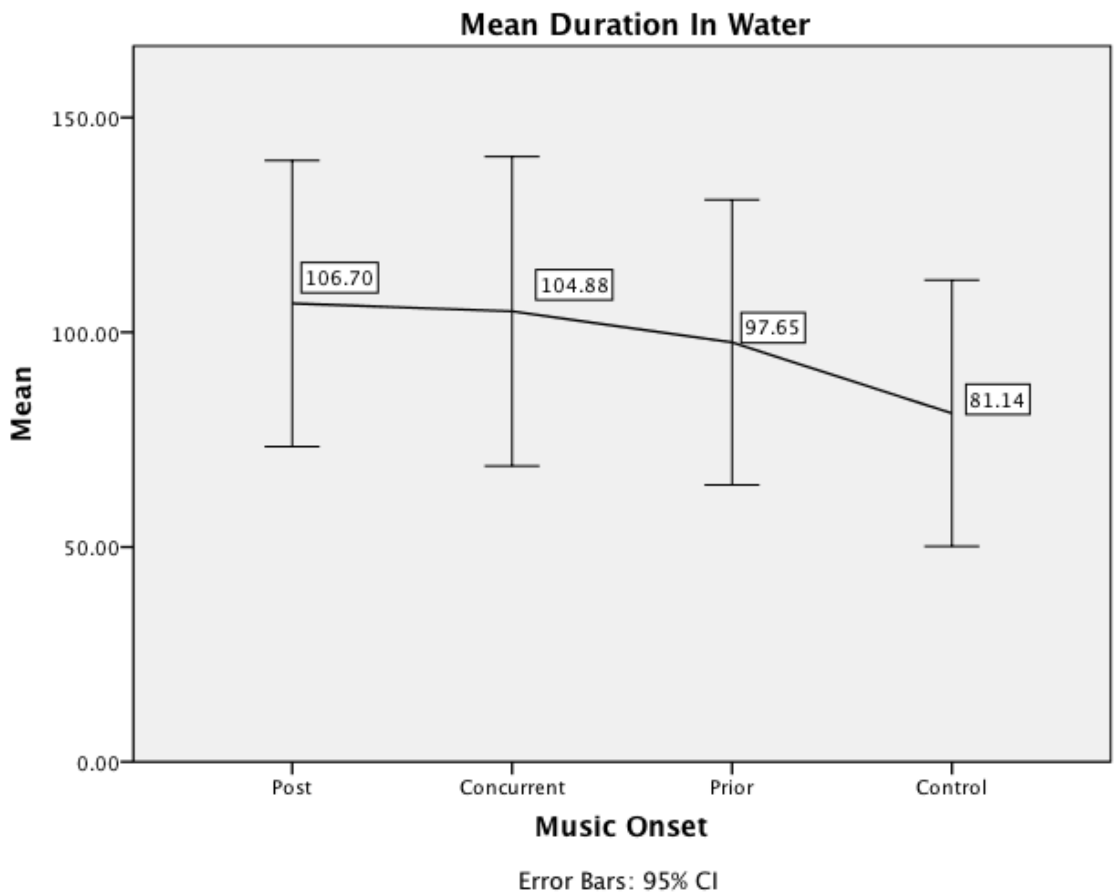


Fig. 1 Subjects' self-reported ratings of pain on a visual analog scale from 0-100 by condition.
*Denotes significance as compared to silence, p<.05

Pain tolerance: Duration exposed to adverse stimulus

Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(5) = 16.16$, $p < .006$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .679$). The results show that the duration subjects kept their hands exposed to the adverse stimulus was not significantly affected by the onset of the music, $F(2.04, 44.81) = 1.56$, $p > .05$.



Research question 1

"Will the use of a self-selected piece of music during a cold pressor test positively impact pain perception?"

The results found that listening to self-selected music during the cold pressor test did positively impact pain perception.

Research question 2

"Will the use of a self-selected piece of music during a cold pressor test increase the duration of time exposed to the adverse stimuli?"

The results did not show a statistically significant increase in duration of time exposed to the adverse stimuli when listening to a self-selected piece of music.

Research question 3

"Will a significant difference be found between the different intervals of time at which the music is introduced on the predictors of; perception of pain and duration of time exposed to the adverse stimuli?"

The subjects did experience a statistically significant difference in perception of pain between two conditions and the control condition. Significance was found for music presented prior to the onset of the cold pressor test and for music presented concurrently with the cold pressor test. No statistically significant differences were found between the music conditions.

No statistically significant differences were found in the amount of time that subjects were exposed to the adverse stimuli between the onset of the music trials.

Results did indicate an average of 25 seconds longer exposure during the condition in which music was presented after the onset of the cold pressor test.

CHAPTER V

DISCUSSION

Visual analog scale: *Self-reported perception of pain*

This study supports the hypothesis that listening to preferred music appears to be an effective method of both reducing the perception of pain and as a method of increasing pain tolerance while experiencing an adverse stimulus. The results of the visual analog scale (VAS) demonstrated a significant difference in self-reported measures of perceived pain during two different trials. The prior and concurrent conditions resulted in a statistically significant effect on self-reported measures of pain when compared to the silent condition. As a result, subjects listened to their chosen song and then reported experiencing less pain during those two trials.

The third trial, which presented music 30 seconds after the onset of the adverse stimulus, did not yield a statistically significant modification in pain perception when compared to silence. These results indicated that presenting music after the fact is not an effective way to decrease the perception of pain in subjects who were exposed to an adverse stimulus.

There were no statistically significant differences between the on-set and perception of pain. This indicated that as long as music was presented at the same time or before the onset of a painful stimulus, music would be effective at reducing the amount of pain that a person would perceive.

Pain tolerance: Duration exposed to adverse stimulus

In terms of pain tolerance, the subject's behavior was recorded by number of seconds that they kept their hand submerged in the cold water. It was found in the behavioral set of data that the third trial (music 30s after onset of music) indicated subjects were able to endure an average of 25s longer than the other conditions. This being said, the results suggest that when an individual needs to endure pain, introducing a musical stimulus shortly after they begin to experience the adverse stimulus will allow them to tolerate that stimulus for longer.

This may have significant clinical implications for practicing clinicians. The findings suggest the introduction of music after exposure to an adverse stimulus may be able to help individuals endure for an average of 25s longer, when performing or are being exposed to a variety of therapeutic movements, medical procedures, or activities. This procedure may provide clinicians with an affordable, non-pharmalogic noninvasive method of enduring uncomfortable or painful situations.

This is very applicable for clinicians working in acute care settings where patients are asked to undergo painful procedures that get worse over time, such as a burn care unit. Patients undergoing debridement would benefit from having a method for lessening their pain with a non-pharmalogic option, since they already have significant amounts of medications being prescribed. Another situation in which providing patients with a method to help them endure a painful situation longer is children with cerebral palsy who need to have stretches performed to help with their rigidity and muscle tension. These stretches can often be uncomfortable and difficult for the children to undergo, so providing preferred music could offer them enough relief and distraction to finish the stretches more easily.

Interestingly, one participant stated that they kept their hand submerged in the water because they "…just really wanted to hear the end of the song". It is noteworthy that someone would choose to continue to expose themselves to an adverse stimulus so they could listen to the last bit of a song they really enjoy. This comment reinforced how important it is that music is self-selected by each individual, to provide the greatest impact.

Comparison between outcome measures

The results from the self-reported measure and the behavioral data had conflicting conclusions. The participants rated their level of discomfort lessened by listening to music prior to and concurrently with the onset of the adverse stimuli. But behaviorally, the subjects were able to tolerate longer in the cold water when they were given music 30s after the onset of the adverse stimulus.

Therapeutically, this poses an interesting challenge for clinicians. The results suggest that psychologically patients benefit from listening to music before and at the start of uncomfortable stimuli but would actually be able to physically tolerate longer periods of being exposed to the same stimulus if music were presented after the fact. These findings will challenge clinicians to weigh the possible pros and cons of both applications, to determine what would be most beneficial for their clients.

These results, conflicting physiological and behavioral data, are not unique to this project. Previous studies have also noted that there are inconsistencies between the two types of data collected. Davis & Thaut (1989) experienced similar findings during an experiment investigating the physiological and psychological responses to listening to subject-preferred relaxing music. The data they collected indicated that state anxiety was significantly reduced but that the subject's physiological responses showed that the music '…aroused and excited rather than soothed autonomic and muscular activity" (Davis & Thaut, 1989).

Musical choices

The musical choices of the subjects were from a broad range of genres. The songs varied greatly in terms of tempo, instrumentation, and rhythm. The only consistent characteristic of the songs were that they were self-selected by the participants. Two subjects did pick the same song (Bon Iver, "*Skinny Love"*) but there were no other duplicated songs (See Appendix D).

The 'alternative' genre was the most common choice by participants, with 6 of the 23 choosing a song from this genre. Pop and classical were next, with 4 participants picking each genre. R&B, folk, metal, jazz, soundtrack and New Age were the rest of the genres chosen by participants.

Limitations

What is typical for this type of research is the use of a circulating refrigerated cold-water apparatus. As described above a bucket and ice were utilized for this project, which could be perceived as a limitation. However, the water was monitored before each trial to maintain a temperature of 5°C (+/- 0.5°C) although could not be automatically circulated during the trials.

Suggestions for future research

This study provides data that may inform clinical decision making for the use of music as a non-pharmacologic analgesic option for patients. The onset of music as a pain mediation stimulus may be differentially indicated based on the nature of the procedure.

For instance, future research could examine the amount of pre-procedure time indicated to be most effective toward pain perception and tolerance. A common duration of a pop/rock song is slightly more than 3 minutes. It is currently unknown if a longer induction period would differentially impact any of the outcome measures and if listening to a song in its entirety prior to exposure to adverse stimuli would have an impact on the outcome measures. Following controlled laboratory studies, translational research would be required to examine clinical efficacy.

APPENDIX A

Health Questionnaire

Participant #: ______

Please indicate "X" in the corresponding space for each line:

Health Condition	**Yes**	**No**
Heart condition		
Circulator condition		
Blood pressure issues		
Recent serious injury		
Chronic pain		
Diabetes		
Epilepsy		

If you have any questions regarding any of these conditions, please ask the researcher for clarification.

APPENDIX B

Research Study Questionnaire

Participant #: ______

Research Study Questionnaire

Age: ___________

Sex: ___________

Have you had any musical training, e.g., take lessons, play or sing in your school band or choir?

Yes No

If yes:

How many years? ___________

What instrument? ____

Do you use music as a way to relax or lessen anxiety? Yes No

On average, how many minutes or hours of music do you listen to per day? __________

APPENDIX C

Volunteer Flyer

VOLUNTEERS NEEDED FOR RESEARCH STUDY ON MUSIC AND PAIN PERCEPTION

Healthy men and women between the ages 18-55 are being recruited for participation in a research study.

The purpose of this study is to investigate the impact of preferred music listening on pain perception.

Requires:

- A one time, 1-hour time commitment
- No preexisting health conditions (ex: arthritis, heart conditions, neurologic conditions, etc)
- Have no hearing impairments

Flexible scheduling available

For more information, contact:

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APPENDIX D

Participant Song Choices

1.) Bon Iver, “Skinny Love” (x2 subjects)
2.) Sufjan Stevens, “Holland”
3.) Pixies, “Where is My Mind?”
4.) Otis Redding, “The Dock of the Bay”
5.) Lauren O’Connell, “I Would Rather Be Gone”
6.) Mumford & Sons, “After the Storm”
7.) Lamb of God, “Boot Scraper”
8.) Duffy, “Syrup & Honey”
9.) Del Amitri, “Nothing Ever Happens”
10.) Eric Whitacre Singers, “Sleep”
11.) Meditation Spa, “Blissful Moments”
12.) Ray LaMontagne, “Shelter”
13.) Claude Debussy, “Claire de Lune”
14.) Ben Folds, “Time”
15.) A Great Big World, “Land of Opportunity”
16.) Youngblood Brass Band, “Brooklyn”
17.) Romero Lubambo, “Song for Kaya”
18.) Hans Zimmer, “Time”
19.) Mumford & Sons, “Lover of the Light”
20.) Louis Armstrong, “That Lucky Old Sun”
21.) Robert Shumann, “Carnaval, Op. 9: V. Eusebius”
22.) Justin Timberlake, “Not a Bad Thing”