PSYCHOPHYSIOLOGICAL RESPONSES OF ANXIETY OR STRESS TO AUDITORY CHANGES IN MUSICAL CHARACTERISTICS

by

SASHA MAHARAJ

A mini-dissertation in partial fulfilment of the requirements for the degree of

MA (RESEARCH PSYCHOLOGY)

in the Department of Psychology at the

UNIVERSITY OF PRETORIA

FACULTY OF HUMANITIES

SUPERVISOR: DR NICOLEEN COETZEE

DECEMBER 2021

DECLARATION OF ORIGINALITY

Full name: Sasha Maharaj

Student Number: u15033695

Degree/Qualification: MA Research Psychology

Title of mini-dissertation: Psychophysiological responses of anxiety or stress to auditory changes in musical characteristics

I declare that this mini-dissertation is my own original work. Where secondary material is used, this has been carefully acknowledged and referenced in accordance with the University's requirements.

I understand what plagiarism is and am aware of the University's policy and implications in this regard.

01/12/2021

Date

Signature

LETTER FROM THE EDITOR

Olivia van Zyl
FREELANCE EDITOR
082 413 6558
olivia.vanzyl@gmail.com
www.linkedin.com/in/oliviavanzyl

To whom it may concern

The following exists as a confirmation letter to affirm that I, Olivia van Zyl, edited the Master's dissertation/mini-dissertation of Ms. Sasha Maharaj for the period of July 2021 to November 2021.

The edit consisted of a basic academic edit with referencing included.

If there are any further queries, please address them to my email, which can be found above.

Regards
Olivia van Zyl
Editor

10 November 2021

ACKOWLEDGEMENTS

I would like to thank the following people and animals for their support over the past few years:

My mother, who has always been one call away to listen to my highs and lows. Thank you for believing in me, I appreciate everything you do for me. Things would have been much more 'hectic' if I did not have your love and support.

To my father, who has given me endless support and encouragement. I will always be grateful to you for taking such good care of me. Thank you for rooting for me, and always reminding me to *actually* finish my research.

To my 'bros', who have always believed in me for every little thing I do. Thank you for all of the laughs, stories, and complaining. You both are great inspirations, I appreciate you.

My friends, Brownie, Laurence, and Mams, we have been through thick and thin, and I will forever be grateful for all the love and support you have given me. It has been a 'hectic' three years, but we got each other through it, while somehow also having fun.

To Dr Coetzee, supervisor supreme, who has always been such an inspiration to me. I appreciate the knowledge, guidance, and understanding you have always extended.

Lastly, to my fluffiest companions, Omar and Buffy, who sat with and on me during countless nights and days working tirelessly. Thank you for all the cuddles, love, and laughs. I did this for you two, to earn a living and support your endless need for food, toys and treats.

ABSTRACT

Anxiety and stress are both widely experienced responses, which has been linked to reductions in well-being, daily functioning, as well as the development of psychological disorders when unregulated and experienced chronically (Nutt et al., 2008). Both anxiety and stress cause arousal, thereby sharing similar physiological and psychological responses (Shahsavarani et al., 2015). Music therapy is a treatment method often used to quell stress and anxious responses, which is rooted in the physiological and psychological impact of music. This physiological and psychological impact is often attributed to auditory changes in musical characteristics, such as changes in pitch, tempo, intensity and timbre, which has effects on both mood and autonomic arousal (Arjmand et al., 2017). The present study used a scoping review to collate and summarise the breadth of information available about musical characteristics and auditory changes that affect both the physiological and psychological components of stress and anxious responses. A combined and adapted scoping review design outlined by Arksey and O'Malley (2005) and Levac et al. (2010) was used in the present study. The addition of a data extraction tool (framework used from Bussiek et al. (2018)) was part of the adaptations to the outlined methodology, as well as the final stage of the process being a review of rigor. The current study found that there are 21 relevant studies that fit the scope of the research, which indicated that recent research is limited and that no local South African research had occurred. Final conclusions show that further research to expand the scope of recent research and to clear up contradictions in the literature is necessary.

Keywords: Psychophysiology, anxiety, stress, auditory changes, musical characteristics

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

1.1. Introduction

Auditory stimuli have been studied extensively across various domains in relation to its effects on humans (Alagha & Ipradjian, 2017; Modeme & Sunday-Kanu, 2014; Morgenstern & Auhagen, 2006; Osmanoglu & Yilmaz, 2019). Recorded effects have been emotional, educational, psychophysiological or socio-cultural in nature, which consequently forms the basis of music therapy (Morgenstern & Auhagen, 2006). The current research undertakes a psychophysiological perspective, which is defined as a multidisciplinary approach to human functioning and experience that considers the relationship between mental and physical processes to understand the complexity of them (Cacioppo et al., 2007).

Anxiety is experienced psychophysiologically, which includes both psychological and physiological arousal and symptoms usually caused by a state of apprehension (Mochcovich et al., 2016). Due to this state of apprehension, current levels of anxiety resulting from an internal or external stimulus, can cause high levels of tension and concern of approaching and future situations, as well as complete avoidance of situations that can end up being maladaptive to the human being in the long run (Maina, et al., 2016). Although everyone experiences anxiety in some capacity, chronic states of it can extend into anxiety disorders that then affect general wellbeing and quality of life. Cognitive escalation of anxiety also frequently occurs, which is the increasing fearfulness that is perceived from the threat. Anxious thoughts result from the initial sense of anxiety and is accompanied by somatic symptoms such as a rapid heartbeat and breathing rate, cardiovascular irregularities, dizziness and general physical uneasiness (Moss, 2002).

The somatic symptoms of anxiety are those of an elevated heart rate, increased respiration rate and excessive sweating (Nabi et al., 2010). These symptoms have been related to anxiety in various studies with increased heart rate and respiration rate being connected to hyperventilation, in instances of anxious apprehension, and feelings of panic. Furthermore, sweating or increased skin conductance (due to the elevated moisture of skin causing it to become more conductive) has also been continuously connected to uneasiness experienced during anxious states (Pittig et al., 2012).

Associated with anxiety is stress, with evidence coming from both experimental and clinical studies. These studies mentioned that stressful circumstances arising from environmental and emotional factors can be the precursor to anxiety disorders (Ray et al., 2017). A recent study conducted by Tanguy et al. (2018) described anxiety as a moderator of

stress responses as well as the adaptation to stressors. Furthermore, the authors conversely delineated that state anxiety acts as a mediator to stress responses, while suggesting that context is not the only influencing factor. Much debate exists when considering the relationship between stress and anxiety, however both influence physiological arousal in that there is a decrease of heart rate variability (HRV) which is the variations in time between each heartbeat (Chalmers et al., 2014; Kim et al., 2017).

Mottaghi et al. (2015) mention that music therapy is often used to treat mental disorders, especially those of hyperarousal, such as those disorders or symptoms related to anxiety and stress. Music therapy (MT) and music based intervention (MBI) taps into the emotional, psychological and physiological changes that occur through different processes involved with music (playing, creation or listening to music within a group or individualised setting) (Hohmann et al., 2017). Further research has established links between correlates of anxiety and stress and certain auditory characteristics, such as Bartlett's (1996) research which found that music with a fast tempo, rhythm and intensity resulted in increased tension and physiological arousal. However, due to its dated nature this matter should be reinvestigated.

Chapter 1 provides insight into the rationale and motivation for conducting the present research study. Providing further motivation for the current study, the aim and objectives are described. Lastly, Chapter 1 includes a chapter outline, which indicates the expected content for each chapter that follows.

1.2. Research Problem

Despite apparent psychophysiological symptoms of anxiety and stress, the Mental Health Foundation (2014) indicate that anxiety is highly under-treated and under-diagnosed. The authors suggest that anxiety might be under-diagnosed and under-treated due to its diverse experience, and the subsequent verbalization of such experience (Mental Health Foundation, 2014). Similarly stress is also often under-treated, with Devi et al. (2019) mentioning that this could be due to stress being a part of normal human life, however, stress in excess can become maladaptive, much like anxiety (Devi et al., 2019; Mental Health Foundation, 2014). Negative physical, emotional and cognitive effects may arise due to maladaptive anxiety and stress, such as cardiac diseases, insomnia, agitation, disorganization, and a lack of concentration, among others (Devi et al., 2019; Moss, 2002). Considering the severe effects that the symptoms of stress and anxiety can have on an individual, it is important to have continual research and investigation into treatment or intervention methods that may be more effective. The current research study is therefore significant, whereby the research summarises and provides an

analysis on recent results, and provides recommendations for future research to address anxiety and stress from a music therapy perspective.

Furthermore, literature on the details of auditory changes in music therapy on a South African population is limited. Pavlicevic (1999) investigated MT within a South African context, by looking at how music therapy impacted children who have suffered trauma, such as domestic violence. Pavlicevic (1999) concluded that individuals respond to auditory changes that might not be musical in nature, such as changes in timbre, rhythm, tempo, phrasing and intonation, because of the human disposition to communicate non-verbally. Although Calitz (2017) investigated the effects of liturgy singing and music on grief, emotions, anger and depression in South Africa, existing literature that looks into acoustic cues and its effects on the arousal on anxiety in South Africa is limited and dated.

Further considering the need for additional research in the field, Panteleeva et al. (2017) explain in their meta-analysis that the more recent research on the subject is conflicting in nature, as well as much research being unquantified. Due to conflicting results, dated information, and the need to identify effective ways to address anxiety and stress, current research should be synthesised and collated to direct future research and recommendations.

1.3. Aims and objectives

The aim of the research study is to provide an overview and investigate the breadth of information available about psychophysiological responses in anxiety or stress to auditory changes in musical characteristics. The research also identifies population characteristics and sample sizes included in the investigated of the stipulated scope. Finally, this research study aims to identify research gaps and map conflicting results, so that it can be addressed by future researchers.

The objectives of the research study are as follows:

- To identify population characteristics included in the investigated of the stipulated scope.
- Uncover research gaps and map conflicting results, so that it can be addressed by future researchers.
- To provide an overview of the amount of knowledge that is accessible about psychophysiological responses in anxiety or stress to auditory changes in musical characteristics.

- To summarise, map and collate the available knowledge according to types of existing evidence and populations.
- Recommend areas of focus for future researchers by identifying research gaps and conflicting results.

1.4. Chapter outline

The first chapter of the current research study introduces the background context, research problem, rationale and aims and objectives of the research study. Chapter two delves into the relevant literature, exploring the different psychophysiological and musical characteristics considered in the study. Chapter three follows and presents a step-by-step approach of the adapted scoping methodology used to analyse the data. Chapter four states the results of the scoping review conducted, broken down into a numerical description and content analysis. Lastly, Chapter five includes the limitations to the current research study, recommendations for future research and the conclusion based on the results uncovered.

1.5. Conclusion

Research investigating the psychophysiological responses in stress and anxiety of musical characteristics is limited, dated and conflicting (Iakovides, 2004). A scoping review presents an optimal opportunity to examine the breadth of information available, firstly through a numerical description and secondly, through a thematic description of results. Chapter 1 explored the research problem and rationale for the current research, which provided direction for the aims and objectives. Lastly, this chapter outlined the structure and content of the following chapters. The following chapter will focus on providing in-depth discussions of the key constructs under investigation.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Chapter 2 outlines the empirical basis of the research study by investigating the relevant literature. The chapter focuses on the definitions and impacts of psychophysiology, with specific attention paid to physiological arousal and emotions. An explanation of stress as a psychophysiological process is provided, along with a description of the Diathesis-Stress Theory. Furthermore, utilised within the study is the psychophysiological consideration of anxiety and the State-Trait Anxiety Theory. A discussion of the use of music to alleviate stress and anxiety, along with an analysis of its mapped origin and uses throughout time follows. The auditory characteristics of music is analysed as a factor influencing an individual's musical experience and response due to the inherent musicality of human beings. Chapter 2 concludes by considering research that relates to the role of music in alleviating psychophysiological correlates of anxiety and stress.

2.2. Psychophysiology

As stated in Chapter 1, psychophysiology considers the relationship between the mental and physical processes in humans, with the goal of understanding how they affect one another as well as how they function together (Cacioppo et al., 2007). The following section discusses how physiological arousal and emotions form part of the psychophysiological process.

2.2.1. Physiological arousal

Physiological arousal is defined as the activation of different bodily mechanisms, resulting in a state of wakefulness and the ability to respond quicker (Beri & Reddy, 2019). Shannahoof-Khalsa (2008) explicates that the hypothalamus and autonomic nervous system (ANS) form a central part of the physiological responses that result from psychophysiological states. The ANS is the division of the nervous system that regulates the parts of the body that do not need voluntary control, these include; smooth muscles, cardiac muscles, and glands (Ebnesshahidi, 2017). While previous research has indicated that the hypothalamus and ANS regulate the physiological functions that influence reproduction, and thereby the survival of species, research conducted during the twentieth century has found that the electrical stimulation of the hypothalamus affects both of the established divisions of the ANS. These established divisions include the sympathetic system, as well as the parasympathetic system (Shannahoof-Khalsa, 2008).

According to Svorc (2018), the hypothalamus is a highly complex structure that participates in regulating most bodily functions, these functions include; hunger, food intake,

thirst, emotions, endocrine glands, and sexual functions. The hypothalamus is also involved in controlling biological processes, these biological processes include the sympathetic and parasympathetic division. Pop et al. (2018) also establish the hypothalamus as the regulatory centre for the ANS, which by establishing connections to other parts of the brain, has certain excitatory effects on certain biological processes. These biological processes include; the regulation of breathing, the heart rate (HR), and the thermoregulation of the body through sweating. Previous researchers, including Shannahoof-Khalsa (2008) and Svorc (2018), have proven that autonomic responses are regulated through the hypothalamus. This was proven by experimenting with electrical pulses. These experiments consisted of electrical pulses being sent through different regions of the hypothalamus. These pulses resulted in changes in salivation, HR, sweating, bladder contractions, and defecation (Shannahoof-Khalsa, 2008; Svorc, 2018).

The parasympathetic nervous system is known to have an inhibiting effect on organs and muscles; this results in the preservation of the body's resources. The parasympathetic nervous system is key to saving and restoring energy. It does so by reducing HR, blood pressure, respiration rate (RR), and promoting digestive functions. The sympathetic division of the ANS functions as the opposite of the parasympathetic division as it mobilises bodily resources for emergencies, thereby enabling fast responses. This causes HR, blood pressure, and RR to increase, while digestive functions are inhibited. Consequently, physiological arousal is influenced by the activation of the sympathetic division on the ANS (Ebnesshahidi, 2017; Weiten, 2014).

There are various physiological indicators and measurements of arousal, the first of which being changes in HR (Beri & Reddy, 2019). HR is measured by monitoring heartbeats per minute (bpm), and is similarly affected by the ANS (Sacha, 2014). HR is related to HRV, which has been established as a predictor for a number of life-threatening diseases. When there is autonomic system arousal HR increases, consequently HRV decreases. HRV is an increasingly new and non-invasive method of measuring an individual's general wellbeing, as well one's cardiac function. This measure is often used in conjunction with fitness training in order to determine an athlete's wellbeing, however; it can also serve as an important indicator of health deficiencies. These deficiencies include but are not limited to; lack of sleep, unhealthy eating, and stress (Blascovich et al., 2011; Sacha, 2014).

According to Cretikos et al. (2008), RR is often neglected as a vital sign of serious diseases such as, cardiac arrest and respiratory illnesses. RR is measured using breaths per minute and relative changes in RR have been seen as an indicator of serious illness. This is

significant when compared to changes in HR or blood pressure, as they do not serve as such a notable indicator. Cretikos et al. (2008) suggest that RR can be a clear indicator as to whether patients are stable, or if they are at risk of cardiac or respiratory illness.

Another effect of the sympathetic nervous system is electrodermal activity (EDA). EDA is the term used to describe autonomic changes in the electrical characteristics of the skin. The most frequently used property of the skin is skin conductance level (SCL). EDA consists of SCL combined with skin conductance response (SCR). The difference between SCL and SCR is that SCL measures the background tonic (muscular contraction) of the skin, while SCR measures rapid phasic responses. EDA is considered a highly reliable indicator of sympathetic system arousal caused by various emotional and cognitive states. The measurement of EDA is quantified by calculating the current flow of an administered electrical potential between two points of skin contact (Braithwaite et al., 2015; Rosebrock et al., 2017).

Physiological arousal of the ANS has also been linked to emotional experiences and emotional processing. A subject's mood has shown to have a positive correlated relationship with biological functions. Similarly, healthy living through nutrition and physical activity has been associated with mood arousal (Beri & Reddy, 2019). Extensive research has been conducted regarding the relationship between emotion and physiological arousal. Particular attention has been paid to physiological arousal caused by music.

2.2.2. Emotions and music

Emotional arousal refers to an individual's reaction to an emotional stimulus, thereby resulting in an affective state (Deckert et al., 2019). Valence forms part of affective states; it refers to the pleasant or unpleasant experience of the emotional stimulus (Volkinburg & Balsam, 2014). Emotions experienced during an affective state can be classified according to specific categories, these categories include; happy, angry, sad, or surprised. For example, an affective state can be derived from an emotional stimulus that causes high emotional arousal of anger, which will also cause a negative valence.

Emotions are thought to be experienced subjectively when elicited by a stimulus, with emotions also holding a function for humans. There is no one universal theory for this function, but some researchers have hypothesized that emotions can create a picture of an individual's surrounding environment. Emotion can be viewed as 'human data' and can be used in conjunction with other forms of data, such as sensory inputs (Mordka, 2016). Frijda and Mesquita (1994) cite action readiness and appraisals as functions of emotions. Furthermore, Frijda and Mesquita (1994) define emotions as appraisal processes that can lead to changes in

actions or behaviours. While the term 'appraisal' is indicative of cognitive processes, emotions are inferred from a subject's self-reports when an event is experienced. While the function of emotion is widely theorised, numerous research studies have determined that emotions can be self-regulated to a certain degree (Weiten, 2014). Although most individuals possess a self-regulating ability, the occurrence of emotional elicitations can hinder the biological processes needed to regulate emotions (Weiten, 2014). Davidson (2006) notes that the human conscious tends to be unaware of automatic emotional responses; an example being response timing, which is rooted in the functioning of biological structures. The above theory is reinforced by the previous statements by Shannahoof-Khalsa (2008) and Pop et al. (2018) regarding the hypothalamus and its designated role in the management of emotions and the regulation of the ANS.

Recent research on the psychophysiological responses of individuals to music and acoustic characteristics has been focusing on the relation between emotions and valence. In a study by Lundqvist et al. (2009), it was found that happier music tends to result in increased facial muscle activity, lower finger temperature, and increased SCR. Ultimately, the results suggest that emotions can be spread and induced through music. Congruent with this, a study by Stevenson et al. (2016) also mentions that happy music results in an increased HR and EDA. Furthermore, Stevenson et al. (2016) express that the opposite is true for sad music.

Similarly, Mori and Iwanga (2017) investigated the psychophysiology of emotion evocating music, specifically music that elicits a teary or chill response. Furthermore, the findings suggest that EDA and arousal increase when chills are experienced, while the presence of tears results in slower respiration. Despite the physiological differences in responses, the experience of tears and the experience of chills induced through music are both considered pleasurable. These findings suggest that there exists a considerable difference between the psychophysiology of both tear-, and chill-inducing music. It also suggests that psychophysiological responses can be used to provide more information on beneficial auditory stimuli.

In a similar vein, Ronan et al. (2018) conducted a study investigating the effects of the quality of musical production on participants' emotions. High quality production and low quality production were differentiated according to a high and low quality mix. Participants were given a questionnaire in order to measure experienced emotions as well as the various physical physiological changes that presented themselves, these measures included; facial expressions, head nodding, and shaking. The participants were divided according to their degree of listening, which is defined as how critical they are when listening to music. The

results indicated that critical listeners have a greater emotional response when considering music production quality than the less critical listeners do. Conclusively, Ronan et al. (2018) note that music with high production quality may only matter to a small subset of individuals; the subset consisting of individuals who possess a trained ear for melody and lyrics. While production quality may elicit a greater emotional response from the abovementioned subset, many researchers have questioned the validity of music as a tool for communicating emotions to listeners (Juslin, 2013).

In order to investigate the consistency of emotional communication, Juslin (2013) identifies three distinct layers regarding the effect of musical expression on an individual's emotions. The separate layers each focus on the different forms of coding that affect emotional meaning, which has proven to be linked to music and emotions. The first layer concerns iconic coding. Iconic coding refers to the physiological responses and emotional expressions that present themselves while an individual is listening to music (Juslin, 2001; Juslin 2013). Juslin (2013) defines iconic coding as the base layer of musical communicative content. The reason being that this layer, which is inferred from vocal expressions and basic sounds or characteristics in music, allows listeners to express basic emotions rather than complex emotions. The term 'basic emotions' refers to emotions that are experienced on a daily basis, however; Juslin (2013) states that this definition of basic emotions should only be utilised in a context where music invokes perceived emotions. Iconic coding is considered the 'core' layer due to its global presence, as it does not differ drastically from culture to culture.

The second layer is concerned with intrinsic coding. Intrinsic coding refers to the basic composition of music and how the various musical elements interact with one another. The second layer is also concerned with how the relationship between the different musical elements influences the human body, a few effects include; changes in tension, relaxation, and emotional height. These effects have been linked to the arousal and perception of complex emotions. For example, the arrangement of different musical elements can communicate tension as an emotion, however; changes in time (tempo) and composition throughout a song can change the variations of the tension (Juslin, 2013). Furthermore, Juslin (2013) notes that variations between different cultures affect intrinsic coding more so than iconic coding due to the variations in musical elements having a plethora of different meanings in different cultures.

The third layer is defined as associative coding. Associative coding refers to how individuals derive meaning from different musical arrangements (Juslin, 2013; Sloboda, 1999). Associative coding differs from intrinsic coding as it involves both general and personal associations. It also focuses on how individuals link certain events to different musical

compositions. General associations refer to connections made between different social experiences and certain sound combinations. This is in contrast to personal associations, which relate to the personalised connections individuals derive from certain musical compositions which leads to the deduction that the third layer is responsible for invoking the most complex of emotions (Juslin, 2013). The first layer of iconic coding is therefore the most relevant regarding the current research study because it suggests that musical elements have the ability to induce emotional responses without having to formulate complex meaning codes. It suggests that basic sounds and inflections have the ability to affect human physiology, as well as the most basic everyday emotions.

However, the theory that music has the ability to elicit emotion is contrary to what Chuen et al. (2016) discover in previous research. Chuen et al. (2016) found evidence that acoustic factors can have physiological effects on an individual without initiating changes in emotion. The research was conducted by recording the participant's physiological responses to simple auditory changes and the changes occurring after periods of isochrony (also known as rhythmic repetition). The study found that simple changes in *certain* acoustic characteristics, specifically; timbre, intensity, and changes in time (tempo) increased SCR, while *all* characteristics tested, namely; pitch, timbre, intensity, duration, and deviation from isochrony affected HR. Hunter et al. (2010) reaffirm the results; finding that there is a relevant amount of contention as to whether music can cause a genuine evocation of emotion. This contention, similarly identified by Eerola and Vuoskoski (2012), is caused by the large amount of variation in research approaches, definitions, and measurements of emotions that have been utilised by various researchers.

2.3. Stress

Stress is a rather common occurrence in human psychology, therefore; it has become a research topic frequently explored in several fields (McCraty & Tomasino, 2006). Stress's common occurrence is highlighted by the various models and definitions present within modern research, which focusses on; the emotional, social, biological, and psychological effects of stress (Shahsavarani et al., 2015). The following section explores the various definitions and effects of stress through utilizing a psychophysiological approach.

2.3.1. Definition of stress

Stress can be defined as psychological and physiological pressure or tension, which can be caused by an individual's internal state of mind and external environment (Shahsavarani et al., 2015). McEwen (2014) notes that stress is experienced both emotionally and physiologically. McEwen (2014) also notes that chronic and recurrent stress can result in

feelings of loss of control, as well as emotional and physical exhaustion. Furthermore, stress is initiated by the activation of the sympathetic nervous system, which causes a physiological response.

2.3.2 Stress as a psychophysiological process

Stress affects various aspects of human physiology; one physiological aspect being HRV. A study conducted by Masaoka and Homma (1997) found an increase in RR when participants completed a stress task, which also correlated with the participants' state anxiety scores. Additionally, Masaoka and Homma (1997) recorded a higher EDA response than that of the baseline measurements when participants were confronted with a stressor. Interestingly, the EDA response data showed different mean amplitudes for different types of stressors (Lutscher, 2016). Reviewing this evidence highlights the strong link between the physiological effects of anxiety and the physiological effects of stress.

A meta-analysis conducted by Kim et al. (2017) found substantial neurobiological evidence that stress affects HRV to a substantial enough degree for it to be a suitable measurement. Following upon the previous finding, HRV is also associated with multiple stress factors, these include; an individual's coping mechanisms and abilities, lifestyle choices, and stressful situations and their duration. Furthermore, physiological factors such as breathing, posture, and sleep cycles can also affect stress (Kim et al., 2017).

A recent measurement of stress is that of the Cardiac Stress Index (CSI), which utilises HRV data collected through the observation of electrocardiography (ECG) and converts it into CSI. HRV and CSI are therefore considered analogous, which then provides a current measure of cardiac stress load on the heart (Henning, 2014). CSI greater than 20% is indicative of above average cardiac stress (Aghamohamadi et al., 2010). However, while HRV is considered an accurate measure of autonomic arousal, Persad et al. (2012) state that more peer review and research is needed in order to establish the relevancy of CSI.

The physiological symptoms of hyperarousal associated with stress is accompanied by a psychological toll, which influences general wellbeing (Spielberger & Reheiser, 2009). Stress can cause various emotional responses, and while there is a large variety of emotional correlates, some are more likely to be experienced than others are. Typically, stress can cause feelings of annoyance, anger, anxiety, apprehension, sadness, and grief. A psychophysiological perspective of the emotions experienced during stress leads to the conclusion that stress is initiated by the perception of a stimulus perceived as threatening. Furthermore, emotions resulting from this perception can go unmanaged, which will then result in maladaptive stress

responses (Lazarus, 1993; McCraty & Tomasino, 2006; Weiten, 2014). The recurring emotions caused by stress can disrupt internal emotional processes, cognition, and attitudes. Such disruptions include; the manifestation of self-doubt, unhappiness, discontentment, and insecurity (McCraty & Tomasino, 2006).

Research conducted by Du et al. (2018) found that academics agree that there exists a relationship between stress and negative emotions. The research also found that negative emotions experienced by university students increases when there is an increased level of stress. Furthermore, there search investigated the concept of rumination. Rumination is the thoughts that individuals have about stressful events or feelings. An increased level of rumination during a high level of stress was also observed by Du et al. (2018). Consequently, it was established that a higher level of negative emotions is experienced during high levels of stress.

Researchers have also investigated the impact of stress on an individual's academic performance. A recent study conducted by Pascoe et al. (2020) investigated the effect of stress on students in secondary school and in higher education. Pascoe et al. (2020) concluded that stress formed by an increase in academic demands should be considered a major concern for both tertiary and secondary educators. The research shows that continuous stress will have a negative impact on; academic performance, learning capacity, sleep quality, sleep quantity, physical health, mental health, and the ease of employment. Furthermore, Pascoe et al. (2020) assign significant importance to instilling stress-management skills for the reduction of stress.

While stress is an unpleasant experience from both a physiological and psychological standpoint, stress can also be the cause of positive emotions. For example, the presence of gratitude during a stressful period is defined as a positive emotion. The heightened sense of relief, or any other positive emotion, can help students cope with stress. It can also help promote a higher level of resilience through stressful periods. The transformative abilities of positive emotions have long been documented through religious, medical, artistic, and psychological explications. Therefore, in a movement towards reducing stress, positive emotions are often the target of transformation (Lazarus, 1993; McCraty & Tomasino, 2006).

2.3.3. Managing Stress

The mechanism of 'coping' refers to the efforts individuals make to reduce, or tolerate, stress levels; this is known as a common behavioural response to stress. The management of stress can be helpful and beneficial to an individual's health, however; it may also have a maladaptive effect. While healthy coping mechanisms can better both the situation and oneself,

it can also lead the habit of blaming others and indulging oneself (Weiten, 2014). Research has indicated that indulging in certain activities is directly linked to stress, these activities include; the excessive drinking of alcohol, under or over-eating, smoking, and over-spending of money (Park & Iacocca, 2013; Weiten 2014). Furthermore, Park and Iacocca (2013) indicate that while individuals have the ability to note that these overindulgent activities are unhealthy; a stressful situation still tends to deplete the availability of the willpower needed to resist such behaviours.

Schneiderman et al. (2005) state that a stressful situation can elicit different responses based on the intensity of the stressors and the controllability of the situation. Stanton et al. (2001) also mention that different facets of stress can have additive effects that are more intense and more difficult to control. While the type and number of stressors are two factors to consider, stress-related outcomes are also dependent on personal and environmental factors. One such factor includes personal risk. Personal risk may be the result of a psychopathological state or previous trauma. An individual's personal situation can influence the amount and nature of the available coping resources (Schneiderman et al., 2005). Furthermore, Kendler et al. (2003) indicate that stressful life events, meaning those that fall within the domains of loss, danger, and humiliation, are related to developments of major depressive and generalised anxiety disorders.

Various studies have determined that anxiety is linked to stress; with recent studies suggesting that anxiety as a trait can function as a moderator in stressful situations; therefore influencing how individuals alter their behaviour in these situations. Tanguy et al. (2018) explain that anxiety is often considered a part of an individual's personality; which will then affect whether or not that individual will have a certain response to a stressful situation. Tanguy et al. (2018) also discuss that state anxiety, as an experienced mood, will modulate the response once there exists a response to the stressor. These responses can influence the intensity of the behavioural, physiological, emotional, and cognitive responses an individual may have to the stressor in question (Hainaut & Bolmont, 2005; Tanguy et al., 2018).

McLaughlin and Hatzenbuehler (2009) discuss anxiety sensitivity. Anxiety Sensitivity is defined as the fear of experiencing symptoms of anxiety that have resulted from the belief that the social, physiological, and psychological effects are harmful. Among adolescents, anxiety sensitivity is shown to increase panic-like and anxious symptoms. A significant factor influencing the development of anxiety sensitivity is the presence of stressors, particularly unpredictable stressors. Additionally, research has indicated that stressful life events increase

the development of anxious symptomatology in children and adolescents (McLaughlin & Hatzenbuehler, 2009; Nolen-Hoeksema, 2017).

Another factor to consider is that increased anxiety and stress may exacerbate other psychological issues, these issues include an increased risk of post-traumatic stress disorder, or generalised anxiety disorder (Mills et al., 2014). A study conducted by Zarbova and Karabeliova (2016) identified no significant differences in stress responses based on gender, age, or education. Nevertheless, negative correlations between levels of stress and wellbeing, happiness, and life satisfaction are still observed.

2.3.4. Diathesis-Stress Theory

The Diathesis theory was initially used in the medical field and was first adopted into the domain of psychology by Paul Meehl in the 1960s. 'Diathesis' itself refers to a certain predisposition. In the context of psychology, the theory relates to the development of psychopathological states initiated by stressful situations (Van Ameringen & Pollack, 2012). As previously mentioned, stress is defined as mental and physiological pressure or tension, which can be caused by an individual's internal state of mind, or by the external environment (Shahsavarani et al., 2015).

Barlow (2002) established a model indicating how stress can cause chronic states of anxiety. The model denotes the diatheses as 'vulnerabilities', more specifically; biological and generalised psychological vulnerabilities. Biological vulnerabilities are the genetic predispositions that increase the chance for an individual to develop psychopathology. The generalised psychological vulnerabilities are formed by an individual's experiences of stressful events, these experiences foster preconceived perceptions of uncontrollability; which are based on the after-effects of those stressful events. Both biological and psychological vulnerabilities influence an individual's ability to tolerate stressful situations. They can also affect one's chance of developing an anxiety disorder. Ultimately, the Diathesis-Stress Theory defines stress as an acting catalyst; a catalyst that leads to the inherent vulnerabilities that modulate whether a chronic state of anxiety will be reached and maintained. The Diathesis-Stress Theory has spurred research; which has determined that stress, as well as stressful life events, commonly precede anxiety disorders (Schneiderman et al., 2005).

Utilising a non-specific Diathesis-Stress Model, Joiner and Schmidt (1995) investigated the vulnerability among male undergraduates, with specific focus on the presence of perfectionism, life stress, and the symptoms of depression or anxiety. The research found that males who experienced high levels of life stress and socially imposed perfectionism were at an

increased risk to develop depressive symptoms. Furthermore, a confirmatory factor analysis was conducted from the general negative events composite. The analysis concluded that socially imposed perfectionism has the ability to cause an increase in both depressive and anxious symptoms (Joiner & Schmidt, 1995). These findings were later confirmed by Wang and Saudino, (2011), who conducted a longitudinal study on a cognitive based Diathesis-Stress Theory of peer victimisation, depression, self-esteem, and anxiety among adolescents. A Structural Equation Modelling analysis approach was utilised in order to investigate the mediators of the stress theory. The results indicated that self-esteem mediates the relationship between depressive symptoms and both overt and relational peer-victimisation (Wang & Saudino, 2011). Furthermore, it indicated that self-esteem exists as a mediator regarding the relationship between peer-victimisation (both overt and relational), and anxiety symptoms (Wang & Saudino, 2011).

In another study, Reinelt et al. (2013) identify childhood emotional maltreatments, as well as the serotonin transporter (5-HTTLPR), as vulnerabilities that increase the risk of Social Anxiety Disorder. The reconsideration of vulnerabilities is spurred on by research that links childhood emotional maltreatment to Social Anxiety Disorder (Kuo et al., 2011). Furthermore, additional research was considered, which stated that anxiety is modulated by 5-HTTLPR, therefore suggesting that anxiety is a biological vulnerability (Grigrich, 2002). The research concluded that the genotype (genetic composition) 5-HTTLPR (which includes being female, being of a younger age, and having experienced childhood maltreatment) are all risk factors that increase the chance of developing Social Anxiety Disorder (Reinelt et al., 2013). The Diathesis-Stress Theory is most relevant to the current research as it defines stress as a vulnerability that can lead to the development and maintenance of chronic states of anxiety.

2.4. Anxiety

Anxiety exists as a commonly experienced negative emotion that motivates both defensive and coping behaviours. D'Avanzato et al. (2013) express that unregulated anxiety can develop into psychological disorders. As a result, it is important that more attention should be paid towards developing new and effective treatments. The following section investigates anxiety through a psychophysiological basis.

2.4.1. Definition of anxiety

Schmidt et al. (2018) delineate anxiety as a fear involving the expectation of a harmful agent in either the present or the future. Additionally, Dieleman et al. (2010) state that physiological arousal is also evident in anxiety. Anxiety is a normal experience that has the adaptive function of motivating individuals to take action against certain situations or anxiety

causing stimuli. However, anxiety can become maladaptive and reduce an individual's daily functioning if it is chronic or of severe intensity (Nutt et al., 2008).

2.4.2 Anxiety as a psychophysiological process

Vitasari et al. (2011) studied reduced academic performance resulting from anxiety, and therefore explored physiological arousal experienced by identifying the fluctuation in heartbeat and RR experienced by individuals with anxiety. Other than an increased RR, other researchers have identified higher EDA in individuals with anxiety (Smith, 1976). Croft et al. (2004) have further investigated SCL and its function as a predictor of anxiety caused due to speech related events. Croft et al. (2004) have also investigated HR in relation to public speaking anxiety. It has been mentioned that both situational and chronic anxiety caused by a fear of public speaking show an increased state of arousal.

As previously discussed (see 2.2.1) various researchers have concluded that HR and HRV are related. Sacha (2014) found this relation based off a physiological dependence. In a study conducted by Chalmers et al. (2014), it was found that the presence of a lowered HRV in individuals with anxiety can be indicative of future cardiovascular disease. While the relationship between anxiety and cardiovascular disease is not yet clear, the findings of Chalmers et al. (2014) is consistent with those of Smith and Blumenthal (2011), as well as that of Allgulander (2010) who state that anxiety disorders, which are related to the experience of severe anxiety, increase the risk for cardiovascular issues.

Broadly considering the behavioural changes resulting from anxious states, Nolen-Hoeksema (2017) identifies an increase in avoidance and escape behaviours, as well as aggression and freezing as the main behavioural changes that result from anxious states. Behavioural changes can depend on the anxiety-causing issue; an example being anxiety resulting from an individual's physical appearance. Nechita et al. (2018) found that an appearance-based anxiousness can cause individuals to alter eating and exercising behaviours. In the same vein, Davis and Fischer (2012) found that personality traits, such as anxiety or anger, can also be affected if an individual adapts to a situation in a certain manner; an example being if an individual reacts in a confrontational or avoidant manner (Nechita et al., 2018; Nolen-Hoeksema, 2017). Davis and Fischer (2012) further investigated the influence of personality traits in a previous research study, which concluded that trait anxiety, as well as the inclination to act carelessly when distressed, influences compulsive eating (avoidant behaviour) in participants.

Anxiety has also been shown to affect an individual's cognition through distortions of perception, losing conception of time and space, lowering concentration, reducing learning ability, and hindering the capability of forming connecting relationships and associations. Furthermore, the negative emotions associated with anxiety, such as dread, terror, irritability, and restlessness, can affect an individual's attention. The associated negative effects of anxiety can cause selectivity issues by focusing attention on aspects of the environment that exacerbate anxious thoughts and feelings rather than focusing on what may de-escalate anxiousness. Therefore creating a loop in behaviour and emotions that ultimately increases anxiety. Other cognitive distortions can include; focusing on personal inadequacies rather than situational explanations, selectively focusing on the negative, making excessively pessimistic future predictions, and drawing negative conclusions about oneself from insignificant events (Nolen-Hoeksema, 2017; Sadock et al., 2015; Weiten, 2014).

2.4.3. Managing anxiety

There are various treatments targeting anxiety, however; it is often difficult to control physiological arousal as it is rooted in the ANS, whereby the responses are automatic and reflexive. One treatment includes the use of medication to return bodily functions to a homeostatic state. Due to RR usually increasing during times of stress and panic, medication is usually used *in conjunction* with breathing techniques (Jerath et al., 2015). Jerath et al. (2015) explain why breathing exercises are effective. First, there exists the possibility that meditation can shift the focus from the sympathetic system to the parasympathetic system due to the ANS being moderated by breathing. Second, breathing techniques can possibly serve as a supplement treatment to anxiety, stress, and emotional disorders. Although not a primary treatment, breathing techniques are increasingly used to quell the symptoms of anxiety; an example being the breathlessness experienced during panic attacks (American Psychiatric Association [APA], 2021).

Other treatments take a cognitive-behavioural approach, whereby individuals confront negative and challenging thoughts in order to develop healthy coping strategies. The treatment utilises behavioural techniques, such as monitoring behaviour and behavioural rehearsals, to change maladaptive patterns of thinking. Cognitive-behavioural treatment has proven to last longer than other forms of treatments. Furthermore, due to the comorbid nature of anxiety, cognitive-behavioural intervention is beneficial in that it can also be useful for tackling other present issues (Nolen-Hoeksema, 2017; Weiten, 2014). As mentioned in the start of this

chapter, musical treatment has *also* proven effective, and will be discussed further in the chapter.

2.4.4. The State-Trait Anxiety Theory

This research study is based on the State-Trait Anxiety Theory that was conceptualised by Spielberger et al. (1970). The State-Trait Anxiety Theory delimits two different types of anxiety; the first being state anxiety, and the second being trait anxiety. State anxiety is a temporary emotional state that varies in strength over different lengths of time. The cognizant emotions include; tension, trepidation, and the arousal of the ANS (Spielberger et al., 1970). Such arousal is evident through fluctuations in HR and blood pressure, which is indicative of dysfunction within the cardiovascular system and even intense anxiety (Spielberger & Reheiser, 2009). State anxiety is perceived as situational. This is due to the temporary nature of state anxiety, whereby threatening and stressful situations can cause an individual's emotional state, and arousal, to rise in intensity. Conversely, while trait anxiety encapsulates the same emotional state and autonomic arousal as state anxiety, it is perceived as relatively stable. Individuals with trait anxiety are said to have higher state anxiety, as well as a more deprecating view of themselves. In order to monitor these anxieties, the State-Trait Anxiety Inventory (STAI) has been created as a method of measuring the different types of anxiety experienced (Spielberger et al., 1970; Spielberger & Reheiser, 2009).

Following the conceptualisation of the State-Trait Anxiety Theory, Magnusson (1980) utilises the empirical relation between state and trait anxiety to bolster the theory. It is argued that a trait measure of anxiety consists of situational measurements, which is similar to state anxiety; therefore suggesting that both anxieties require the same content factor. More specifically, Magnusson (1980) defines state anxiety as the measurement of a threatening situation and the subsequent reaction to it, trait anxiety concerns the *general* level of anxiety across *all* situations. The content of the measurement for the two types of anxiety is the same, however; the two exist on different dimensions. Where state anxiety accounts for *intensity* experienced, while trait anxiety accounts for the *frequency*. Lastly, Magnusson (1980) mentions that it would be beneficial for the scale to include other personality fields, such as anger.

Building on the State-Trait Anxiety Theory, Spielberger and Reheiser (2003) have created an instrument that considers other factors responsible for influencing wellbeing, and thereby behaviour as well. The State-Trait Personality Inventory was designed to consider anxiety, anger, depression, and curiosity as emotional states in terms of their intensity and

frequency; therefore matching up with what Magnusson (1980) discussed previously. The scale evaluates emotional states in the same divide of dimension, namely state and trait, while accessing the same content (Magnusson, 1980; Spielberger & Reheiser, 2003).

While reflecting upon the above-mentioned theory, Spielberger and Reheiser (2009) determine that anxiety as an emotional state is central to psychological wellbeing (PWB), due to its overarching effect on cognitive functioning, behaviour, and physiological arousal. Therefore justifying the psychophysiological approach for the research; as it highlights that anxiety as an emotion leads to physiological arousal, which can cause behavioural changes.

2.5. Understanding music

Music has been beneficial to humankind throughout all of history, whether socially or cognitively, the benefits have not dissipated over time. However, before investigating how music can be used to alleviate stress and anxiety, it is necessary to gain a certain level understanding of music. Besides the most common use of music, namely as entertainment, music has always been used for various beneficial purposes. These purposes link to both personal cathartic releases, and therapeutical functions. The following section focuses on the origin, use, development, and elements of music.

2.5.1 Origin of music

The evolutionary origin of music is shrouded in uncertainty, however; it is fascinating to note that music is present throughout multiple human cultures, regardless of the uses and musical behaviours that accompany it (Wallin et al., 2000). Juslin (2013) theorises that music might have evolved from the vocal expression of basic emotions, these emotions including; anger, happiness, and sadness. Furthermore, Juslin (2013) suggests that the vocalisation of basic emotional expressions might have combined with musical vocalisations. The inference extrapolated from this theorised origin is that basic emotions have to be tied to effective communication and to an inherent musicality that is ingrained in humans from an evolutionary viewpoint.

In line with Juslin's (2013) theory, it has been found that the earliest recorded use of music was rooted in cultural and social functions; these functions facilitating communication between people, as well as portraying community values and identity (Boer, 2009). While the previously mentioned functions of music are evidenced throughout time, the exact origins and adaptive functions are practically unknown. Despite the lack of knowledge regarding its origin, music is ingrained in various cultures and societies. One current popular use of music includes its appearance at social, religious, and cultural events. Throughout history, these social,

religious, and cultural events entailed group activities that would range from war- to courtship rituals. Ultimately, the essence of music is to facilitate group cohesion. This tradition is still intact in today's modern times, however; it is also evident that the function of music has evolved from simply facilitating social events, to also being beneficial in solitude (Killin, 2017; McDermott & Hauser, 2005).

Killin (2017) notes that musical developments have dated as far back as one million years. Throughout the ages, music has proven to facilitate cognitive and social advancements significant to cultural progression, and consequently significant to musicality (Killin, 2017). Boer (2009), Killin (2017), and McDermott and Hauser (2005) express that these social and cognitive advancements relate to the various uses of music throughout history. Historically, music has served as a social facilitator for both courtship and group socialisation; which has in turn led to the development of various cultures, social functioning, and the facilitation of communication within groups. In terms of cognitive advancements, music has impacted cognitive processes linked to memory, these cognitive processes include the mechanisms used for perceiving melodies and musical structures, as well as those necessary for encoding music to memory (Killin, 2017).

2.5.2. Benefits of music in current society

A study conducted by Sloboda (1999) investigated the everyday uses of music. The most common identified uses of music fall within four main functions, namely; aiding memory, providing sensorial or mood effects, creating a spiritual experience, and entertainment during activities. In terms of memory, the participants of the study explained that music has often served as an associated trigger or reminder of a valued past event. Sloboda (1999) further indicated that participants also considered music to be a mood enhancer, changer, or a sensorial evoker. Additionally, music is used for the betterment of moods, thus including; the creation of cathartic release, motivating, exciting, and comforting the listener (Sloboda, 1999). Participants identified various activities wherein music is most commonly utilised. These activities each fit certain personal lifestyle preferences. To mention a few activities, participants listened to music when; waking up, bathing, working, cleaning, eating, driving, and reading. Additional benefits of music have been linked to psychological and physical functioning.

Habibzadeh (2015) discusses the effect of music on mental and physical performance by establishing that music has a wide range of psychological and physiological benefits evident across diverse populations, benefits that include; enhancing memory, improving learning

strategies, focusing attention, and bettering physical coordination. Habibzadeh (2015) further discusses the impact that music can have on physical performance; an example being the increase in endurance that music can encourage. Research has illustrated that certain types of music can have an improving effect, which in turn causes the release of immune-boosting hormones (Kuhn, 2002).

The cognitive effects of music have been investigated as well. One investigational review considers how musical training, or education, affects cognitive development (Miendlarzewska & Trost, 2014). The review indicates that music proves beneficial for children; specifically by improving verbal memory, secondary language pronunciation, executive functions, and reading ability. The review establishes music as a modulating variable to cognitive development, as it can have differing effects on individuals, depending on when and what musical intervention is initiated. Furthermore, research indicates that musical training, or education, is beneficial because of the inherent musicality present in humans (Chuen et al., 2016; Juslin, 2013; Miendlarzewska & Trost, 2014; Pavlicevic, 1999).

2.5.3 Elements of music

The composition of a musical arrangement can have a direct impact on its beneficial nature, as certain elements of music can be used to promote certain therapeutic functions. Musical compositions are built out of smaller components, or elements, that comprise the entirety of musical experience (Murrock, 2016). These elements include the composition's auditory and acoustic characteristics. The elements of music will be discussed next.

2.5.3.1 Tempo

One specific auditory characteristic pertaining to this study is tempo. In its simplest definition, tempo is the speed of at which a sound arrangement is set (Schmidt-Jones, 2003). Tempo is largely used in musical pieces to set or convey a specific mood such as; sadness, happiness, excitement, delight, or depression. Within a musical composition, tempo is often conducted through the use of Italian terms that describe the stylistic manner in which the tempo should be incorporated (Cook, 2012; Lui et al., 2018; Pilhofer & Day, 2007). One example would be the term *Andante,* which means 'at a walking tempo'.

Tempo is measured in beats per minute (bpm). Bpm constitutes a specific speed and mood. For example, a very slow tempo will range from 40-50 bpm and can express either a stately or a solemn mood. The mood can then be reinforced by the use of other appropriate musical elements. A moderate tempo can range from 100-120 bpm, with 120 bpm being

considered the preferred listening pace as it conveys feelings of pleasantness. Lastly, a very fast tempo is defined by a bpm of 160-200, and is associated with different moods, such as excitement or stress, however; it is influenced by the composition of the musical piece (Schmidt-Jones, 2003; Moelants & McKinney, 2004; Lui et al., 2018).

2.5.3.2 Pitch

Pitch is an auditory element that corresponds to how high or low a musical note is (Schmidt-Jones, 2003). Using a scientific definition, music is comprised of sound waves that cause vibrations of air particles, which are then picked up by the eardrums. Pitch is determined by the frequency of these sound waves. It is then measured in Hertz (Hz), which is the number of sound waves per second. High frequencies produce high notes while low frequencies produce low notes. To the human ear, audible sounds range from 20-20 000 Hz, which can also be associated with specific moods (Petersen, 2001). Higher pitched sounds are often experienced as happy and positive, and may even convey immediacy, whereas lower pitched sounds evoke feelings of sadness, dread, or suspense (Pilhofer & Day, 2007).

When considering the musical composition, Huron (2006) states that utilising musical composition structures in certain ways can result in positive responses. Pitch proximity is an important structure, as it leads to music eliciting a more pleasant response from a person. Pitch proximity can be described as the listener's expectation of the next pitch sequence in a musical arrangement. The closer the pitches are to each other, the more predictable, and consequently the more positive, the response will be. The positive response is due to the listener's expectations being met according to how they think music is generally structured (Huron, 2006).

2.5.3.3 Intensity

The intensity of a musical piece refers to the loudness or volume of a sound. It is similar to tempo and pitch in the sense that it can have an impact on the mood of the piece (Pilhofer & Day, 2007). Crusius (2018) mentions that changes in intensity during a musical composition should be essential in order to ensure that there is no stagnation in sound, therefore keeping songs interesting.

Intensity is similar to pitch as it is also influenced by the characteristics of a sound wave, however; intensity is measured in decibels (dBA) and is affected by the amplitude of a sound wave (i.e. its height). The intensity of a sound will not impact, nor will it be impacted, by the pitch or frequency of a soundwave. While two different sounds can have the same

frequency (pitch), the sound may differ in dBA (intensity). For example, a sound of 60 dBA can hold the same frequency as that of a sound of 40 dBA (Petersen, 2001).

Certain sounds with an excessively high dBA can be harmful to the human ear. Consequently, Petersen (2001) classifies specific sounds on a scale of average dBA, for example; rustling leaves fall near a 20 dBA range. General conversation falls around 60-70 dBA, which is deemed an acceptable level of intensity as volumes painful to the human ear only start at 120 dBA. It is important to note that not everyone agrees with Petersen (2001)'s classification. An example being Schmidt-Jones (2005). Schmidt-Jones (2005) argues that rustling leaves should rather fall in the 10 dBA range. Nevertheless, researchers agree that comfortable and safe listening ranges fall within 60-75 dBA. However, The Hearing Health Foundation (n.d.) notes that extended periods (over 24 hours) of listening to music at this intensity can cause hearing damage.

In music theory, intensity is changed throughout compositions to affect the mood of listeners, and is utilised in conjunction with tempo in order to convey the emotion of a musical composition. Examples include an increased intensity for agitation or excitement, or a decreased intensity for sadness and sorrow (Pilhofer & Day, 2007).

2.5.3.4 Timbre

Timbre is considered the 'colour of music' because it is the description of the distinguishing element of different sounds. For example, a sound being played at the same pitch by two *different instruments* will sound different. Timbre is the unique quality of a sound or instrument. Rather than having a formal *measurement*, as observed for the previously mentioned elements of music, timbre is identified using *language*. Some words used to describe timbre include; flat, warm, piecing, harsh, dark, light, and clear. As expected, these types of descriptions have a large impact on the mood or emotion conveyed by instruments. How these instruments are played tends to influence tone quality (Schmidt-Jones, 2003). Inferred musical excitement, which is commonly used in cinematographic productions, is an example of timbre utilised for the creation of a mood. One example being how a violin can be used to create a sense of urgency (McAdams & Giordano, 2008; Pilhofer & Day, 2007). Tension is most often conveyed through the use of piano or violin, as piano tones are most commonly used to convey *spontaneous* excitation while violin tones infer a *continuous* excitation (McAdams & Giordano, 2008).

2.5.4. Using music to alleviate stress and anxiety

Based off the established role of music in historic society, it is evident that music still functions as a form of therapy and cathartic release. There are different forms of music-based therapy with various studies proving the effectiveness and beneficial nature of each music-based therapy.

2.5.4.1. Music to alleviate the psychological impact of stress and anxiety

As mentioned in Chapter 1 (see 1.1.), MT is a process where therapists provide musical intervention. MT can be compared to MBI, in that there is no therapist involved in the process. MT and MBI can be utilised by means of the following processes; listening to music, creating music within a group or individually, or by therapist and client participating in various musical activities (Hohmann et al., 2017). When it comes to anxiety, musical treatment is used to treat the effects of different types of anxiety, such as; test anxiety, pain anxiety, social anxiety, performance anxiety, and generalised anxiety (Zarate, 2012).

Pain anxiety and its reaction to MT is a widely studied topic. Pothoulaki et al. (2008) conducted a study to investigate the effect of music on anxiety and pain perception of patients undergoing haemodialysis treatment. The participants selected were those experiencing anxiety and pain due to renal failure. As an intervention method, the participants were given a variety of music from which they could choose. Pre-test and post-test measures were administered by using the STAI. The control group did not listen to any music, but rather took part in other activities, such as; reading, sleeping, and watching television. The results indicated that the state anxiety of the participants improved significantly after musical intervention. Furthermore, there was a significant increase in the intensity of the perceived pain for those in the control group. Pothoulaki et al. (2008) concluded that music can be used as an effective intervention within medical settings where anxiety and pain is experienced.

Similarly, Imran et al. (2017) considered the effect of music therapy on anxiety, blood pressure, and respiratory rate in patients undergoing chemotherapy for the first time. The study's experimental group was scheduled to have a session of music therapy for 60 minutes. This session entailed the subjects selecting what music they preferred and listening to it while laying on a musical pillow; which is a pillow connected to a portable music player. Anxiety level was measured by using the STAI, with the findings indicating that music has a positive significant impact on state anxiety, blood pressure, and RR. Imran et al. (2017) concluded that music holds the potential to improve therapeutic intervention, especially within an oncological setting (Imran et al., 2017).

Another study investigated the effect that music would have on test anxiety, test performance, and grade consequences for undergraduate learners, citing that most students experience a higher level of anxiety than normal during tests (Lilley et al., 2014). A mathematical test was utilised in order to measure performance. Participants were split into two groups, with each group listening to different types of music. One group listened to calming music while the other listened to disruptive music. The results indicated that the group listening to calming music displayed a reduction in systolic blood pressure and HR when listening to music while studying and completing the test. Furthermore, it was found that test performance was significantly reduced in the group that listened to the disruptive music. Test performance reduced even further for the participants who were told that the test would have a large impact on their grade. It was concluded that the act of listening to certain types of music while studying can be utilised as a tool to reduce test anxiety and better test performance. Additionally, it was noted that harsh music increases HR, with the possibility that it increases a student's focus on the grade consequences as well, therefore reducing overall performance (Lilley et al., 2014).

Further research on the response that university students have to classical music in terms of well-being and anxiety has been conducted by Osmanoglu and Yilmaz (2019). Participants were given a listening schedule. This schedule stipulated that participants should spend a certain amount of time listening to classical music every day for an uninterrupted 60-day period. The State-Trait Anxiety Inventory and the PWB Scale were administered both before and after the musical intervention. The results indicated no significant impact on state anxiety scores, however; there was a significant statistical change in trait anxiety scores and PWB. Regarding well-being, a noteworthy change was found in environmental mastery, personal growth, purpose in life, and self-acceptance (Osmanoglu & Yilmaz, 2019).

In a study where anxiety and stress was induced in participants by utilising a mental arithmetic test, Jiang et al. (2016) consider musical preference a mediator when it comes to reducing anxiety and stress. Music was chosen according to the level of valence it elicited as well as its familiarity to the participants. The research study was based on self-reports of participants' levels of arousal, valence, state anxiety, tension, music preference, and familiarity. Participants listened music on headphones. The results defined the degree of musical preference as a mediator in the levels of tension and anxiety experienced by participants. Jiang et al. (2016) cited the most important factor allowing for the reduction in stress to be the degree to which participants like the music, not the degree of familiarity. It was concluded that both stress and anxiety are partially mediated by musical preference.

O'Hagan (2016) researched the relationship between the act of listening to music and the feelings of anxiety and happiness present in young adults. By utilising a correlational method, O'Hagan (2016) investigated the effects of music on an individual's mood. This was explored by administering a self-made questionnaire that measured the effects of music on participant's moods, as well as by the Burns Anxiety Inventory [BAI] (1999) in order to indicate a level of anxiety. For the study, the type of music was not considered as a factor influencing anxiety. This lack of consideration was accounted for by the self-made questionnaire, as well as by allowing participants to specify what musical genre they listen to while experiencing certain moods. The results found a decrease in anxiety levels in both male and female participants while they were listening to their chosen music (O'Hagan, 2016).

In another study, Crusius (2018) investigated the musical effect on anxiety by creating a piece of music that followed the Therapeutic Function of Music (TFM) Plan worksheet. The TFM worksheet was initially created by Hanson-Abromeit (2015) to guide the composition of musical elements and other components for therapeutic functions. The TFM recommends that a composer consider the nature of the wanted change and the listener's need for auditory changes during a musical piece during composition. In combination with the musical composition, Crusius (2018) reviewed extensive literature, concluding that the optimum tempo for anxiety reduction is between 60 and 80 bpm. Crusius (2018) also notes that sounds not exceeding 60 dBA are preferable, and that gentle or mild timbres should be utilised to alleviate anxiety, the timbres include; piano, flute, and string instrumental sounds.

In addition to research on the relationship between music and anxiety, the effect of music on stress has also been widely researched. Rita and Adaobi (2014) define music as an enhancer of well-being that alleviates life's daily worries and problems. The process of learning how to play a musical instrument, or the process of playing a musical instrument, has been found to improve mathematical understanding and social skills. It has also been established to stimulate both sides of the brain. With this in consideration, Rita and Adaobi (2014) investigated the effect that music performance therapy, namely the act of performing music, had on the ability of academics working at Nigerian federal universities to manage stress. The research defined 'the act of performing music' as a form of therapy involving the playing of musical instruments, vocalising musical tones, fingering musical instruments to produce sounds, and public art performances. The study's findings indicate that musical performance should be considered a significant mood-changer, which acts as a stress relief activity that promotes the relaxation of muscles and engages the brain in a meditative state. The findings also indicate that musical performance increases the chance for an individual to focus on

positive emotions. Additionally, study participants listed strategies perceived as the most useful for stress management, these strategies included; performing and watching musical performances, singing songs that they are comfortable with, dancing to appealing music, and playing certain musical instruments (Rita & Adaobi, 2014).

While the process of performing music is helpful with reducing stress, the sedatory effect of music through slow tempos has also been used to quell anxiety and stress responses (Lehrer et al., 2007). A study conducted at Mindlab International (n.d.) investigated individuals' physiological responses to certain songs while completing a puzzle. Ultimately, ten songs were defined as 'extremely relaxing'; therefore reiterating the possibility that certain underlying components of these songs affect individuals (Curtin, 2017). Arjmand et al. (2017) reaffirm this suggestion by allowing participants in a separate study to select their own song, which fit in with a specific emotion. Hereby the researchers addressed various questions related to individuals' subjective responses to music. In conclusion to the study, Arjmand et al. (2017) propose that the manipulation of basic auditory characteristics is a main trigger for both negative and positive emotions.

Panteleeva et al. (2017) summarise the research conducted on the effects of music, anxiety, and the physiological symptoms of anxiety by stating that research on the arousal effects of music is largely conflicting, as some studies find that participants show *no* arousal, while other studies find an *increase* in arousal. Furthermore, little research has been quantified in terms of anxiety and music. The research that does exist is informal in nature with a lack of universal psychological and physiological measurements that provide comparative capabilities. Therefore, this research study is justified as it aims to address the large amount of information that should be scoped in order to understand research gaps and future areas of focus within this field.

2.5.4.2. Music to alleviate the physiological impact of stress and anxiety

As early as 1974, Landreth and Landreth studied the physiological effects of music by utilising auditory tapes or repeated listening sessions that used isolated tones on participants' HR response. Ultimately, a mirror effect was found in relation to tempo and intensity, whereby fast and dynamic tempo resulted in fast and dynamic HR. Similarly, Bartlett (1996) studied states of arousal induced by music. It was concluded that faster tempos and louder intensities result in increased HR, muscle tension, and skin conductance.

In addition to the research focusing on physiological arousal, the effects of differing musical genres and participant preferences has also been investigated. Kelley et al. (2014)

found that participants' musical preferences did not impact levels of arousal, which is contrary to the original hypothesis. The results led the researchers to conclude that habituation of what music participants often listened to had occurred. Habituation occurs when instinctive responses to a repeated stimulus is diminished (Mauss et al., 2003). Huron (2013) describes habituation as a simple learning process that results from familiarity with a stimulus, which includes the filtering out of daily noises that are of low priority. Furthermore, Huron (2013) indicates that the rate of habituation is influenced by factors including; a stimulus's number of presentations, the rate of its repetition, its predictability, and its intensity. Huron's (2013) explanation of habituation accounts for the results found by Kelley et al. (2014), where it was found that participants' familiarity with certain musical preferences was high, therefore indicating that it was most likely the repetition rate of the musical pieces was high as well.

Similarly, Carpentier and Potter (2007) investigated physiological arousal by measuring SCR in relation to different tempos and genres. The researchers utilised two different genres, namely classic and rock, in order to investigate the interaction between genre and tempo. The excerpts of the two genres were compared to silence and it was found that SCR increases whenever there is any form of music playing. Additionally, faster paced songs showed similar results. The investigation into the interaction between genre and tempo yielded the conclusion that there is a quicker activation of an SCR increase for fast tempo classical songs than for fast tempo rock songs (Carpentier & Potter, 2007).

Significantly, Stevenson et al. (2016) acknowledge the discrepancy between results from the various investigations of the arousal of the ANS due to music. It is mentioned that the observation of HR has often produced conflicting results, while RR has been considered the most consistently affected physiological aspect. The study in question attempted to address the differing results by using the song "The Rite of Spring", which was composed Russian composer Igor Stravinsky in 1913. The musical composition contained specific intervals within its harmonic structure. These intervals can be classified as either consonance or dissonance. Consonance occurs when a combination of intervals within a musical composition is experienced as pleasant, while dissonance is the opposite (Stevenson et al., 2016). The results indicate that the appearance of consonance leads to an increase in HR, a decrease in EDA, and no change for RR. The opposite is true for dissonance, which decreased HR and increased EDA, with there still being no change in RR. Furthermore, a fast tempo from the same musical piece showed an increase in HR, RR, and EDA (Stevenson et al., 2016). Stevenson et al. (2016) consequently conclude that physiological changes are evident in relation to the introduction of music, however; due to music's complex nature, the specific structures and changes of musical

compositions and their physiological effects needs to be investigated further. The research conducted by Stevenson et al. (2016) identifies the various conflicting results between studies conducted thus far.

2.6. Conclusion

The discussions presented above established that physiological arousal and emotional changes shape the main characteristics of stress and anxious responses. It further illustrated that music has the ability to influence physiological arousal and emotional changes, therefore also influencing an individual's level of stress and anxiety. Furthermore, the exploration of the origin of music, its functions (from early to modern times), and the elements thereof highlighted why music can affect stress and anxiety levels. The argument established to justify the importance of the present study cited the large body of research and literature available on anxiety, music and stress, and the conflicting results thereof. The following chapter focuses on the research methodology used during the course of this research study in order to collate and understand the breadth of the information available.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

The following chapter explores the methods applied in order to meet the aim of this research study, the aim being to investigate the breadth of information available regarding psychophysiological responses in anxiety or stress to auditory changes in musical characteristics. Furthermore, this chapter explores the processes of the methodological approach, its design, and its purpose. A description of the methods and stages undertaken to complete the research study has been included. This description addresses the procedures utilised in order to accomplish the study objectives. The objectives in question include; the clarification and mapping of population characteristics and sample sizes, as well as identifying research gaps and research conflicts. As a conclusion, this chapter discusses the ethical considerations born from the applied methodology.

3.2. Methodological Framework

In order to address this study's research aims and objectives, a scoping review has been conducted. The main aim of scoping reviews are to determine and analyse research gaps that may exist within a body of literature (Munn et al., 2018). Scoping reviews include a useful framework to employ when faced with an abundance of literature with a complex nature, as well as when the existence of a new area of research that requires review has been discovered (Mays et al., 2001). The methods employed when investigating the aims of the research study have followed the basic steps identified by Arksey and O'Malley (2005), which have further been explained and summarised by Levac et al. (2010). While this study follows the core outline provided by Arksey and O'Malley (2005), the scope of the study is limited. This limitation has prompted an adapted approach, which will be explained in the following section.

3.2.1. Identifying the research question

The initial step of a scoping study includes the establishment of a broad research question, from which the aim and objectives of the research study are derived (Arksey & O'Malley, 2005). The research question and the following definitions of its factors should be clearly defined from the outset, as this helps to establish boundaries of inclusion and exclusion within the scoping study (Levac et al., 2010). Most notably, according to the enhancements stipulated by Levac et al. (2010), the planning of the output of the scoping review should occur within this stage.

The original research question for this study was formulated during the initial proposal stage. It is important to note that the proposal stage occurred prior to the current COVID-19 pandemic that originated in 2019. The study aimed to investigate the following research question: "Do basic auditory changes of musical characteristics have a significant impact on the psychophysiological responses in anxiety or stress of university students?" The research question was designed according to a quantitative design; and would have included a study involving 50 participants. Due to the manipulation of basic auditory characteristics within the experiment, the question was considered experimental in nature (Gravetter & Forzano, 2012). Due to the COVID-19 restrictions implemented after the time of initial conception, along with the evaluated risks to participants from the planned data collection process, the methodology and nature of the research has been reconsidered.

Therefore, the methodological approach of the research study has changed to that of a scoping review. In order to accommodate the new methodology, the refinement of the original research question is required. The research question has been broadened; it now avoids the need for a population group, and allows for a larger literature search (Arksey & O'Malley, 2005). The following research question has been utilised, "What is the psychophysiological impact of auditory changes in anxiety or stress?" The new research parameters (psychophysiological impact, anxiety, stress and auditory changes) originated as the preliminary inclusion and exclusion criteria for this study. These parameters have ultimately been refined as the data collection process continued.

In accordance with the suggestions of Levac et al. (2010), the research study output was also considered during the stage of defining preliminary inclusion and exclusion criteria. The final output produced has been planned as a descriptive numerical result which counts the results of the searches based on specific themes unearthed. The output has also been planned to include a content analysis of the research, which has been based on the themes discovered within the numerical descriptive result.

3.2.2. Identifying relevant studies

The second step regarding identifying relevant studies entails the development of a plan aimed at collecting information. This stage will detail which sources will be researched, and concerns decision making relating to time span, language, and population (Arksey & O'Malley, 2005). This step is imperative when striving for an understanding of the breadth of information that is available. Levac et al. (2010) expands on this step, and suggests that any limitation of the scope should be acknowledged and limitations to the results should be considered.

During the proposal phase for the current study, preliminary decisions were made regarding the language, time span, and population group that would be included within the research study. During the second step of the scoping review, these criterions were reconsidered in order to ensure extensive thoroughness regarding the research process. As with the nature of scoping reviews, the inclusion and exclusion criteria has continually evolved as the search strategies were conducted (Arksey & O'Malley, 2005).

Table 3.1.

Inclusion and exclusion criterions

Criteria	Inclusion criteria	Exclusion criteria	Justification
Anxiety	Definitions of anxiety that fall within the psychophysiological field based on the following definition: *A fear or anxious response that involves the expectation of a harmful agent whether in the present or future (Schmidt et al., 2018).* Psychophysiological correlates of anxiety. Felt emotion experienced due to musical characteristics.	Music or performance anxiety responses that do not include the investigation of the impact of auditory characteristic changes. Perceived emotions from musical characteristics or music as a whole.	Investigate the psychophysiological field of the impact of auditory characteristics on anxiety.
Stress	Definitions of stress that fall within the psychophysiological field based on the following definition:	Music or performance anxiety responses that do not include the investigation of the	Investigate the psychophysiological field of the impact of auditory characteristics on stress.

	A mental and physiological pressure or tension that is either caused internally or by the external environment (Shahsavarani et al., 2015). Psychophysiological correlates of stress.	impact of auditory characteristic changes. Physical stress caused due to exercise.	
Auditory characteristics	Publications including the impact of tempo, pitch, intensity, and timbre on stress and anxiety.	Publications wherein the effects of subjective music listening is investigated. The investigation of full music compositions or songs. The investigation of the effects of singing on psychophysiological aspects. The auditory characteristics of voice and speech. Studies examining Autonomous Sensory	Focusing solely on studies that investigate the effect of specific auditory characteristics, and not subjective descriptions of music.

		Meridian Response (ASMR) as it is a visual and audio stimulus. Film stimuli (the combination of audio and visual stimuli). Investigations into perceived emotion or emotion recognition in music.	
Time span	All publications published between 2010 and 2021.	All publications published before 2010.	Excluding dated research studies and information.
Design and methodology	Experimental designs (including true experimental and quasi-experimental designs). Meta-analyses. Systematic reviews.	Qualitative enquiries. Content analyses.	Investigating quantifiable and measurable aspects of music, anxiety and stress.
Language	English.	All other languages.	Researchers' main home language.
Outcome	Outcomes regarding the impact that auditory changes have on the experience of stress and anxious responses or	Outcomes that report on genres of music or self-selected music. Outcomes that do not explicitly indicate the	To examine studies that answer the aims and objectives of the research study.

	psychophysiological correlates of anxiety or stress. Outcomes that report on the effects of tempo, pitch, intensity, and timbre on stress and anxiety.	effect that tempo, timbre, pitch or intensity have on participants.	

3.2.3. Study selection

Levac et al. (2010) describe the process of study selection as an iterative process. The study selection process involves searching for sources according to certain inclusion and exclusion criteria, which are continually refined as the search proceeds. The starting point for study selection involves the consideration of the research question, which is followed by familiarising oneself with the subject matter through reading and composing a literature review (Arksey & O'Malley, 2005).

The enhancements that have been suggested by Levac et al. (2010) to further clarify study selection involves conducting team meetings at the outset, with the aim of discussing inclusion and exclusion criteria. Additionally, when study selection is occurring, two independent reviewers are needed in order to review article abstracts and full text articles, while a third reviewer should also be available when conflicting views are present (Colquhoun et al., 2014; Levac et al., 2010). The last addition mentioned by Levac et al. (2010) states that reviewer meetings should be held at the start, middle, and end of the study selection process in order to clarify any challenges, decisions, and ways forward (Colquhoun et al., 2014; Levac et al., 2010).

For the current research study, in order to understand the scope of research within its context, a preliminary search was conducted during the literature review stage. "Psychophysiology", "emotion", "music", "auditory characteristics", "psychology", and "physiology" were used as keywords during the preliminary search. It produced one study, which was then added to the data charting document, as it met the inclusion criteria.

Following the preliminary search, a systematic investigation of PsycINFO, PsycArticles, Agriculture Science, Google, Google Scholar, and Sage Journals (Psychology of

Music) was conducted in accordance with the Boolean operators mentioned in Table 3.2. The chosen sources of investigation were selected because they provide a comprehensive overview of the different subject areas, including areas within the physiological, psychological, and musical domain. The main data collection process transpired from May 2021 to July 2021.

Table 3.2.

Results found per database and Boolean operators

	Boolean operators	**Date range**	**Number of results found**	**Number of studies meeting inclusion criteria**
Search strategy: stress, auditory characteristics, and psychophysiology				
EBSCO Host APA PsycInfo	psychophysiology AND music AND stress	2010-2021	32	2
	psychophysiology AND music characteristics AND stress	2010-2021	1	1 (duplicate)
	psychophysiology AND auditory changes AND stress	2010-2021	1	0
	psychophysiology AND tempo AND stress	2010-2021	5	0
	psychophysiology AND timbre AND stress	2010-2021	0	0
	psychophysiology AND intensity AND stress AND music	2010-2021	3	0
	psychophysiology AND volume AND stress AND music	2010-2021	1	0

	psychophysiology AND pitch AND stress	2010-2021	8	0
	psychophysiology AND auditory characteristics AND stress	2010-2021	No results found	N/A
	psychophysiology AND music elements AND stress	2010-2021	No results found	N/A
EBSCO Host APA PsycArticles	psychophysiology AND music AND stress	2010-2021	2	0
	psychophysiology AND music characteristics AND stress	2010-2021	No results found	N/A
	psychophysiology AND auditory changes AND stress	2010-2021	No results found	N/A
	psychophysiology AND tempo AND stress	2010-2021	No results found	N/A
	psychophysiology AND timbre AND stress	2010-2021	No results found	N/A
	psychophysiology AND intensity AND stress AND music	2010-2021	No results found	N/A
	psychophysiology AND volume AND stress AND music	2010-2021	No results found	N/A
	psychophysiology AND pitch AND stress	2010-2021	No results found	N/A
	psychophysiology AND auditory characteristics AND stress	2010-2021	No results found	N/A

	psychophysiology AND music elements AND stress	2010-2021	No results found	N/A
Sage Journals: Psychology of Music	psychophysiology AND music AND stress	2010-2021	8	1
	psychophysiology AND music characteristics AND stress	2010-2021	8	1 duplicate
	psychophysiology AND auditory changes AND stress	2010-2021	3	1 duplicate
	psychophysiology AND tempo AND stress	2010-2021	5	1 duplicate
	psychophysiology AND timbre AND stress	2010-2021	1	0
	psychophysiology AND intensity AND stress AND music	2010-2021	7	1 duplicate
	psychophysiology AND volume AND stress AND music	2010-2021	3	0
	psychophysiology AND pitch AND stress	2010-2021	1	1 duplicate
	psychophysiology AND auditory characteristics AND stress	2010-2021	3	1 duplicate
	psychophysiology AND music elements AND stress	2010-2021	2	0
	Effect of music on stress	2010-2021	278	3 (2 duplicates)

ProQuest Agriculture Science Database	psychophysiology AND music AND stress	2010-2021	181	3
Google Search	"psychophysiology" AND "music elements" AND "stress"	2010-2021	91	1
	"psychophysiology" AND "music characteristics" AND "stress"	2010-2021	27	5
Google Scholar	“psychophysiology" AND "music characteristics" AND "stress"	2010-2021	72	3 duplicates
	"psychophysiology" AND "music elements" AND "stress"	2010-2021	36	3 (1 duplicate)
Search strategy: anxiety, auditory characteristics, and psychophysiology				
Sage Journals: Psychology of Music	psychophysiology AND music AND anxiety	2010-2021	9	2 (1 duplicates)
	psychophysiology AND music characteristics AND anxiety	2010-2021	9	2 duplicates
	psychophysiology AND auditory changes AND anxiety	2010-2021	5	2 duplicates
	psychophysiology AND tempo AND anxiety	2010-2021	7	2 duplicates
	psychophysiology AND timbre AND anxiety	2010-2021	2	1 duplicate

	psychophysiology AND intensity AND anxiety AND music	2010-2021	8	2 duplicates
	psychophysiology AND volume AND anxiety AND music	2010-2021	3	0
	psychophysiology AND pitch AND anxiety	2010-2021	2	1 duplicate
	psychophysiology AND auditory characteristics AND anxiety	2010-2021	5	1 duplicate
	psychophysiology AND music elements AND anxiety	2010-2021	1	0
	Effect of music on anxiety	2010-2021	266	2 duplicates
EBSCO Host APA PsycInfo	psychophysiology AND music AND anxiety	2010-2021	38	1
	psychophysiology AND music characteristics AND anxiety	2010-2021	1	0
	psychophysiology AND auditory changes AND anxiety	2010-2021	1	0
	psychophysiology AND tempo AND anxiety	2010-2021	4	2 duplicates
	psychophysiology AND timbre AND anxiety	2010-2021	No results	N/A
	psychophysiology AND intensity AND anxiety AND music	2010-2021	3	0

	psychophysiology AND volume AND anxiety AND music	2010-2021	1	0
	psychophysiology AND pitch AND anxiety	2010-2021	5	0
	psychophysiology AND auditory characteristics AND anxiety	2010-2021	No results found	N/A
	psychophysiology AND music elements AND anxiety	2010-2021	No results found	N/A
EBSCO Host APA PsycArticles	psychophysiology AND music AND anxiety	2010-2021	2	1 duplicate
	psychophysiology AND music characteristics AND anxiety	2010-2021	No results found	N/A
	psychophysiology AND auditory changes AND anxiety	2010-2021	No results found	N/A
	psychophysiology AND tempo AND anxiety	2010-2021	1	1 duplicate
	psychophysiology AND timbre AND anxiety	2010-2021	No results found	N/A
	psychophysiology AND intensity AND anxiety AND music	2010-2021	No results found	N/A
	psychophysiology AND volume AND anxiety AND music	2010-2021	No results found	N/A
	psychophysiology AND pitch AND anxiety	2010-2021	No results found	N/A

	psychophysiology AND auditory characteristics AND anxiety	2010-2021	No results found	N/A
	psychophysiology AND music elements AND anxiety	2010-2021	No results found	N/A
ProQuest Agriculture Science Database	psychophysiology AND music AND anxiety	2010-2021	161	2 duplicates
Google Search	"psychophysiology" AND "music elements" AND "anxiety"	2010-2021	120	2 duplicates
	"psychophysiology" AND "music characteristics" AND "anxiety"	2010-2021	119	2 duplicates
Google Scholar	“psychophysiology" AND "music characteristics" AND "anxiety"	2010-2021	56	1 duplicate
	"psychophysiology" AND "music elements" AND "anxiety"	2010-2021	30	3 duplicates
TOTAL			1519	17

In total, 1519 search results were investigated across all utilised databases. Once the search strategy was finalised, and sufficient rigorous analysis had been ensured, the sources consulted within the reference lists of the relevant articles were reviewed for additional study selection. This yielded three more studies that met the inclusion criteria.

3.2.4. Data charting

As the next step, the data charting step utilises a narrative review method that is implemented in order to extract the necessary process and contextual information from each individual study. In order to achieve a narrative review, a data charting document is required

(Arksey & O'Malley, 2005). Levac at al. (2010) expands on the data charting step by establishing the need for a research team to collectively clarify the variables included in the data charting document in order to ensure the relevancy to the research question. Much like the study selection process, data charting is an iterative process whereby the data charting document is continually updated. Furthermore, Levac et al. (2010), stress the importance of piloting the charting document to determine whether the document is adequately extracting the correct variables of the research question. As an additional step to enhance the data charting process, Levac et al. (2010) indicate that complex data may necessitate a qualitative content analysis approach.

In order to track the study selection for the current research study, a data charting document was created in Excel. The initial charting document included the title, author, publication date, methodology, population, sample size, and URL link of the selected study. As the study selection process continued, the search strategy and database from which the study was acquired was added to the document for tracking purposes. The final charting document has been included as Appendix C.

3.2.5. Data extraction, summarisation and reporting the results

The original fifth step mentioned by Arksey and O'Malley's (2002) scoping review outline includes the collating, summarising, and reporting of results. The step entails various outputs, the first being a numerical analysis of the breadth of the available information pertaining to the research question. From the numerical analysis, an analytical framework is utilised in order to provide an overview of the literature collected (Arksey & O'Malley, 2002; Colquhoun et al., 2014). Levac et al. (2010) indicate three imperative steps for this stage. First, analysis, this includes both the descriptive numerical analysis and the qualitative content analysis. Second, the reporting of results, which must align with the outputs described during the first research stage. Third, the discussion step, which must relate back to the study purpose and aim to unearth research gaps and recommendations for future research (Colquhoun et al., 2014; Levac et al., 2010).

The current study diverges from the original methods relayed by Arksey and O'Malley (2005), by including a data extraction tool, which assisted with the summarising and reporting phase. The data extraction framework used in Bussiek et al. (2018) was adapted in order to be utilised in the current research study. Table 3 illustrates the criteria extracted, and the justification for each aspect.

Table 3.3.

Data extraction tool

Criteria	Justification
Title	To determine the frequency of publications per year, as well as seminal authors.
Author	
Year of publication	
Sample size	To understand the frequency of sample sizes investigated.
Population (age, gender, specification, or diagnosis)	Documenting the frequency of ages, gender, and diagnosis investigated in the research studies.
Objective	To understand the purpose of the research study, which will allow for a content analysis.
Physiological measurement (CSI, HRV, heart rate, respiration rate and skin conductance)	To determine the frequency, and to focus areas of physiological measurement in relation to auditory characteristics.
Psychological measurement (anxiety and stress measures)	To determine the frequency and focus areas of psychological measurement in relation to auditory characteristics.
Auditory characteristic (tempo, timbre, pitch and intensity)	To determine the frequency of the investigation of each auditory characteristic.

The data extraction tool was also utilised with the aim of calculating the frequencies for the numeric descriptive results (Appendix D). It also allowed the data to be in a comparable format, form which themes could be extrapolated for the content analysis. White and Marsh (2006) describe content analyses as a research method that is flexible and can be utilised in qualitative, quantitative and mixed methodologies. It is a systematic method used to analyse and summarise a scope of research. Ultimately, the data extraction tool was used as a step of the scoping review and content analysis to inform the recommendations of the current study by highlighting key elements of each study.

3.2.6. Rigor

As a further adaptation to Arksey and O'Malley (2005), the current research study deviates in the last step by replacing the consultation stage with rigor. Cypress (2017) defines rigor as a process that should be conducted by the researcher during inquiry and investigation, rather than it being an external evaluation. Rigor of research is ensured by providing a well-documented data collection process in order to identify measures taken to gain a descriptive numerical and understanding of the literatures content. Furthermore, the documentation of the full scoping process will allow for the replication of the research study (Leedy & Omrod, 2015).

A detailed and systematic process was also implemented during study selection process. First, once a search was completed, each article or search result title was reviewed. It was then determined whether a title was relevant to the inclusion and exclusion criteria. If the study was deemed relevant, the abstract was reviewed in order to verify whether the study should be charted on the charting document. If the abstract was unclear, the entire article was consulted with the aim of understanding whether the full scope of the study met the inclusion criteria. Considering Levac et al.'s (2010) suggestions for scoping reviews, it has been understood that there was no research team available for the current research study. Thus, consultations and meetings with teams were not possible; however, the researcher's supervisor was available for consultation when necessary.

3.3. Ethical Considerations

Information obtained with the aim of informing the scoping review will be dependent on publicly available sources and information; therefore, due to the lack of participants, this method of research poses a reduced ethical risk. Irrespective of the reduced ethical risk, ethical approval has been obtained from the Psychology Research Ethics Committee at the University of Pretoria. Due to the previously mentioned lack of human participants, informed consent forms have not been necessary.

3.4. Conclusion

The above chapter discussed the methodology that was used in order to explore the breadth of information regarding psychophysiological responses in anxiety or stress to basic auditory changes of musical characteristics. In accordance with the aims and objectives of the research, Arksey and O'Malley (2005), and Levac et al.'s (2010) scoping review methods were discussed and adapted within the current research in order to better extract and summarise the data. The adapted data collection process was also documented thoroughly, thereby ensuring

rigor and replicability. Finally, the chapter discussed rigor and ethical considerations that were undertaken during the research.

CHAPTER 4: RESULTS

4.1. Introduction

Chapter 4 delves into the descriptive numerical results that were unearthed during the present scoping study. The purpose of which is to highlight key areas and points of interest, while simultaneously providing an overview of the research gaps present within the analysed literature. Chapter 4 also provides a content analysis of the results from the included research studies. The content analysis is based on established themes relating to each musical characteristic that has been included in the current research study. Furthermore, the chapter includes a summary and discussion of the results and musical characteristic themes. Additionally, the chapter discerns certain domains within the current research field that need further investigation. Highlighted points from Chapter 4 are also used in Chapter 5 in order to discuss possible research gaps and to inform recommendations and suggestions for future research.

4.2. Descriptive numerical results

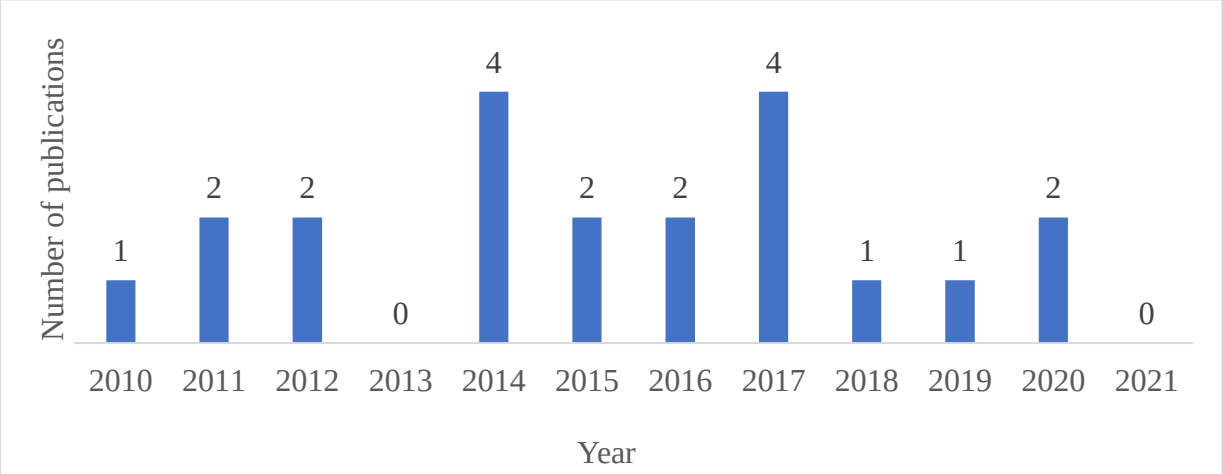
A total of 21 research studies have met the inclusion criteria (see 3.2.2). These research studies are further discussed according to; 1) the number of publications, 2) participant characteristics, 3) the physiological correlates of stress and anxiety investigated, 4) the psychological correlates of stress and anxiety investigated, and 5) the auditory/musical characteristics investigated.

4.2.1. Number of publications

The number of publications released within the established 12-year period peaks in 2014 and then again in 2017, with four publications issued in both 2014 and 2017 (Figure 4.1.). The low number of research studies published during the 12-year period is indicative of a scarcity in the current research material, therefore highlighting a large gap in general research. The research gaps, along with specific areas and aspects within the subject matter, is further discussed in Chapter 5.

Figure 4.1.

Number of publications per year



4.2.2. Participant characteristics

The following section reveals relevant findings regarding; summed gender, mean age, age range, and summed participant population as per the country sample.

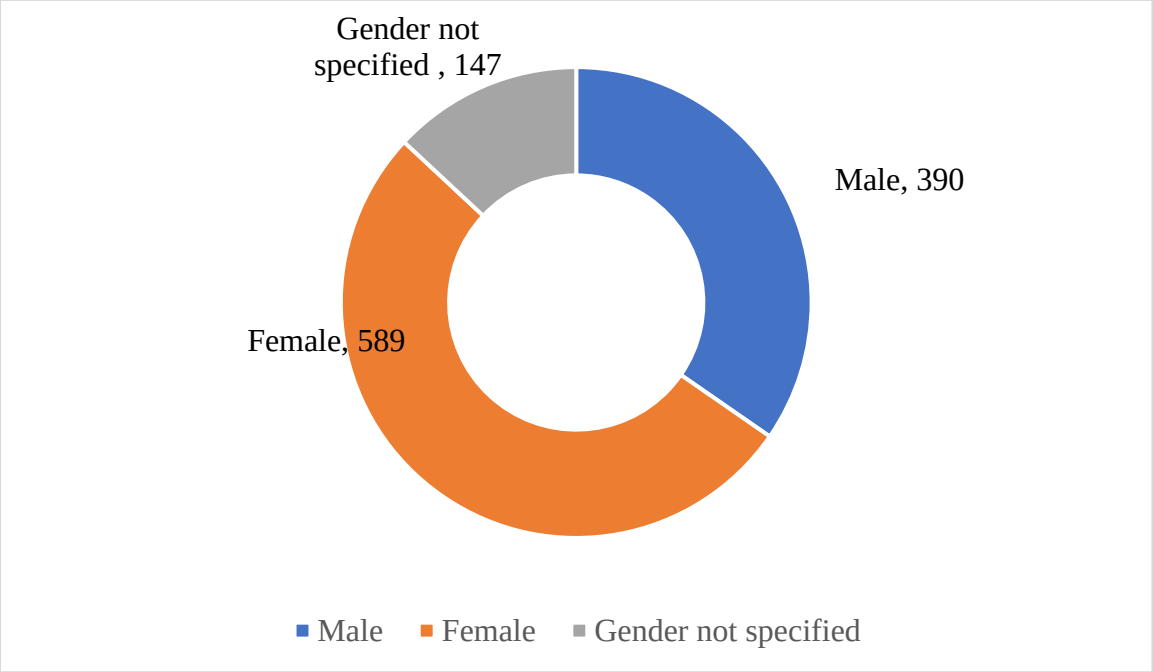
4.2.2.1. Gender

With the inclusion of a meta-analysis comprising of 9 617 participants (Figure 4.2), a total of 10 743 individuals participated in the examined research studies. As an outlier, the previously mentioned meta-analysis might skew the results of participant characteristics, therefore; the total number of participants has been calculated with the exclusion of the meta-analysis. Once the meta-analysis has been removed from consideration, the number of total participants goes from 10 743 to 1 126.

Due to the lack of demographic information available regarding the meta-analysis, further analysis of participant characteristics excludes the meta-analysis and rather focuses on the experimental studies. When considering the gender of participants; the majority was female (n= 589), with the minority being male (n= 390) (Figure 4.2.). Additionally, Figure 4.2. indicates that 174 participants' gender was not specified in the experimental studies.

Figure 4.2.

Gender of participants in experimental studies

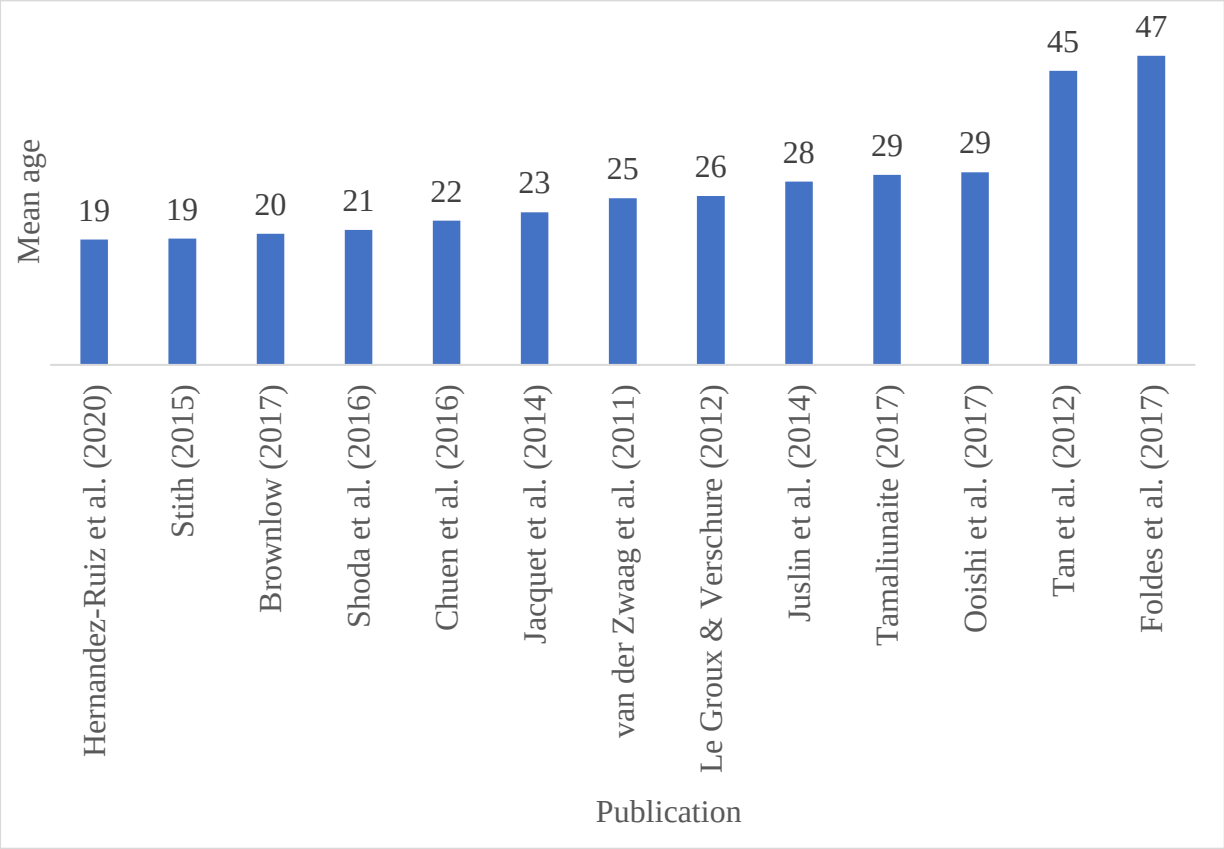


4.2.2.2. Age

Eight research studies did not specify the mean age of participants. However, by analysing the research studies that did specify the mean age of participants, the mean age is estimated to be between 19 and 29 (Figure 4.3.). Two studies had a mean age higher than that of the rest of the research studies. These two studies had a mean age between 45 and 47.

Figure 4.3.

Mean age of participants in experimental studies



The age range established by the studies that included participants' age is presented in Table 4.1. One study included children as participants, while another included adolescents. A few select studies (n=3) only specified that the participants' ages were above 18, while two other studies did not specify any age.

Table 4.1.

Age range of participants in experimental studies

Authors	**Age range**
Kazymov et al. (2014)	15-18
Kim et al. (2018)	Above 18
Tamaliunaite (2017)	18-35

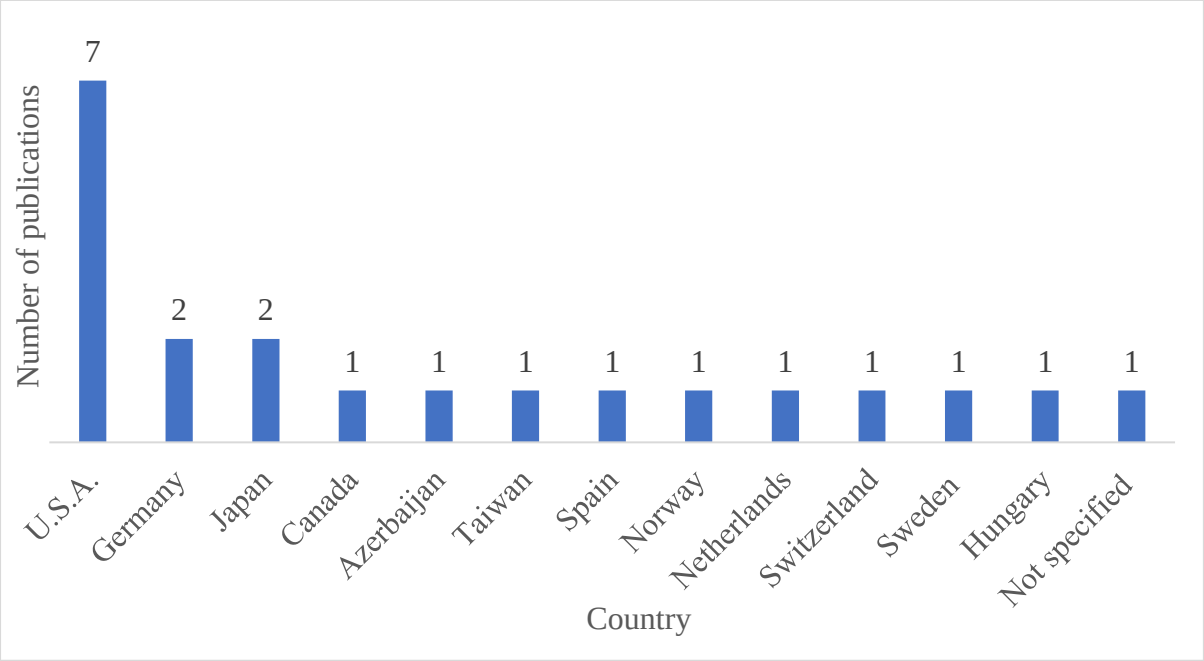
Wang (2014)	Not specified
de Witte et al. (2019)	Above 18
Berger (2011)	8-12
Goldschmidt (2020)	Above 18
Hunter et al. (2010)	Not specified

4.2.2.3. Population (country)

Out of the 21 included research studies, seven studies comprised of participant samples from the United States of America (U.S.A). Furthermore, two studies were conducted with participant samples from Germany, while two studies included participant samples from Japan (Figure 4.4.).

Figure 4.4.

Participant sample population (country) in experimental studies



4.2.3. Physiological correlates of stress and anxiety investigated

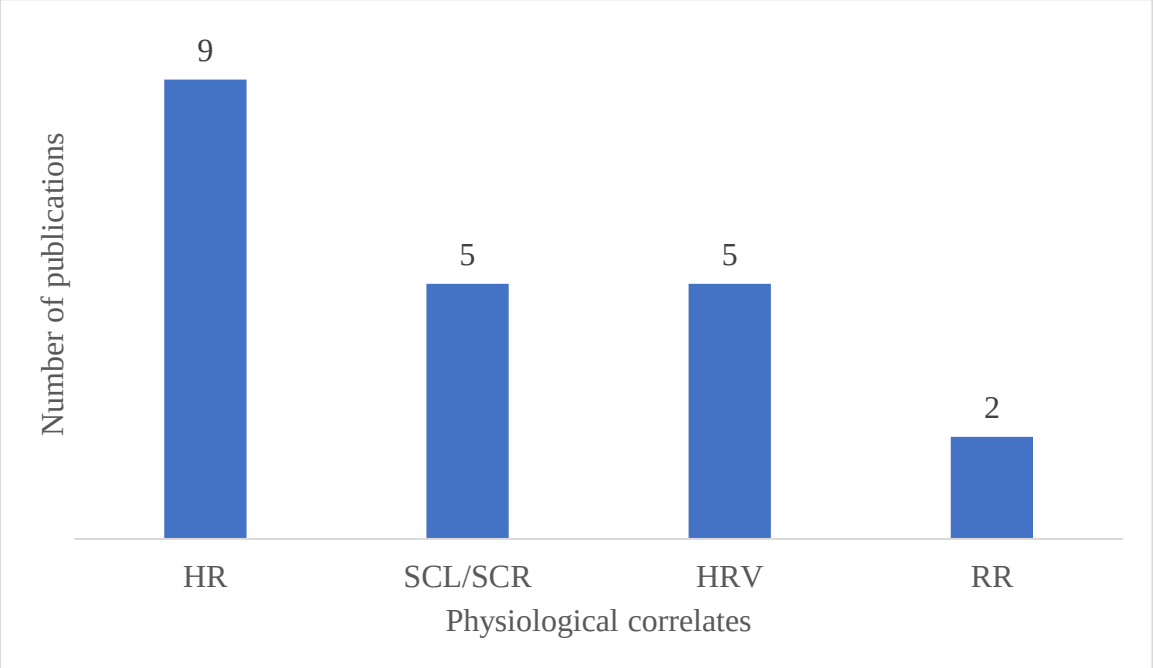
As previously discussed (see 2.3.2 and 2.4.2), anxiety and stress have physiological correlates that affect autonomic functioning. Extensive research has suggested that HR, RR, SCL/SCR/EDA and HRV are to be seen as indicators of physiological arousal during times of stress and anxiety (Aghamohamadi et al., 2010; Croft et al., 2004; Kim et al., 2017; Lutscher, 2016; Masaoka & Homma, 1997; Sacha; 2014; Smith, 1976; Vitasari et al., 2011). Commonly,

fluctuations in HR, RR and SCL/SCR/EDA have been linked to states of stress and anxiety (Croft et al., 2004; Lutscher, 2016; Masaoka & Homma, 1997; Vitasari et al., 2011). Furthermore, HRV as a stress measure of the heart is increasingly being considered as an accurate measurement of autonomic arousal present within individuals with anxiety (Aghamohamadi et al., 2010; Quintana & Heathers, 2014).

When considering the research studies included in the scoping review, nine studies investigated the effects of musical characteristics on HR. Furthermore, HR has been established as the most common studied physiological correlate regarding stress and anxiety. SCL/SCR and HRV are the second most common physiological correlates studied, with five studies each investigating SCL/SCR and HRV's response to certain musical characteristic. Lastly, RR is established as the least studied measure, with only two studies investigating its response to music (Figure 4.5.).

Figure 4.5.

Number of publications investigating types of physiological correlates of stress and anxiety



4.2.4. Psychological correlates of stress and anxiety investigated

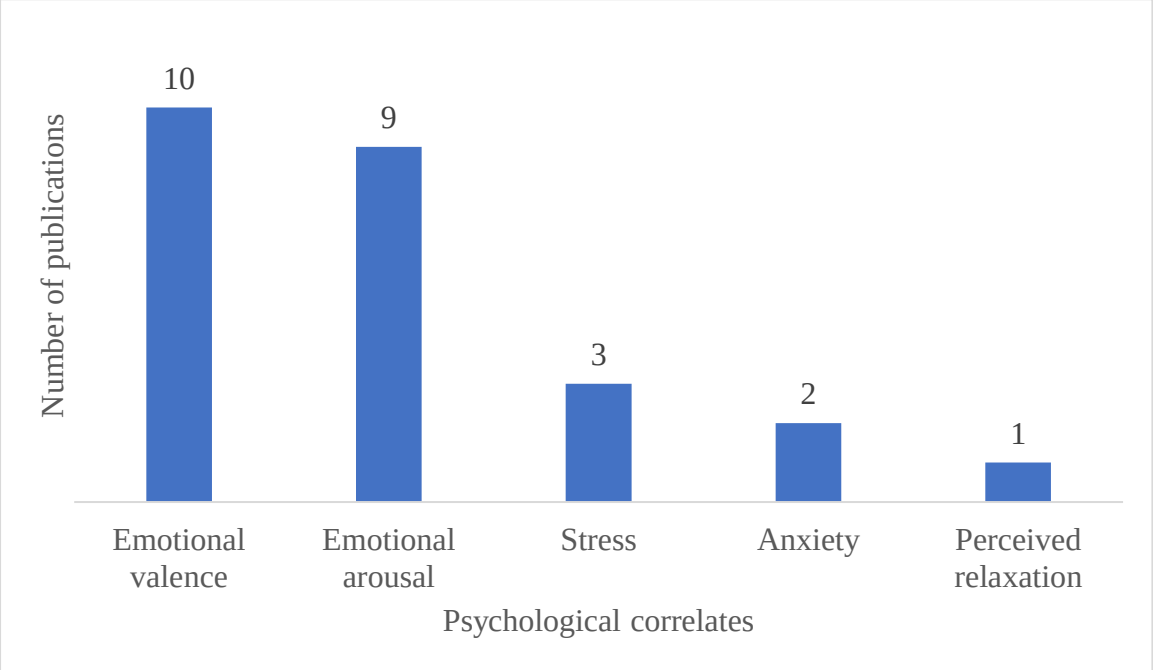
Anxiety and stress have been linked to both physiological and psychological processes (see 2.3.2 and 2.4.2), whereby behavioural and emotional effects are evident as psychological correlates (Nolen-Hoeksema, 2017). As previously established, the psychological impacts of stress and anxiety have been associated with; negative emotions, feelings of unpleasantness (valence), negative behavioural changes, and effects on cognition (Davis & Fischer, 2012; Du

et al., 2018; Nechita et al., 2018; Pascoe et al., 2020; Nolen-Hoeksema, 2017; Sadock et al., 2015; Weiten, 2014).

Emotional valence is the most studied psychological aspect amongst the studies included (n=10). It is followed closely by emotional arousal, in which there are nine published studies. Stress and anxiety are not studied as commonly when compared to emotional arousal and valence. There are three studies with scales investigating stress, and two studying anxiety. Perceived relaxation is also studied in one research study (Figure 4.6.).

Figure 4.6.

Number of publications investigating types of psychological concepts of stress and anxiety



4.2.5. Auditory/musical characteristics investigated

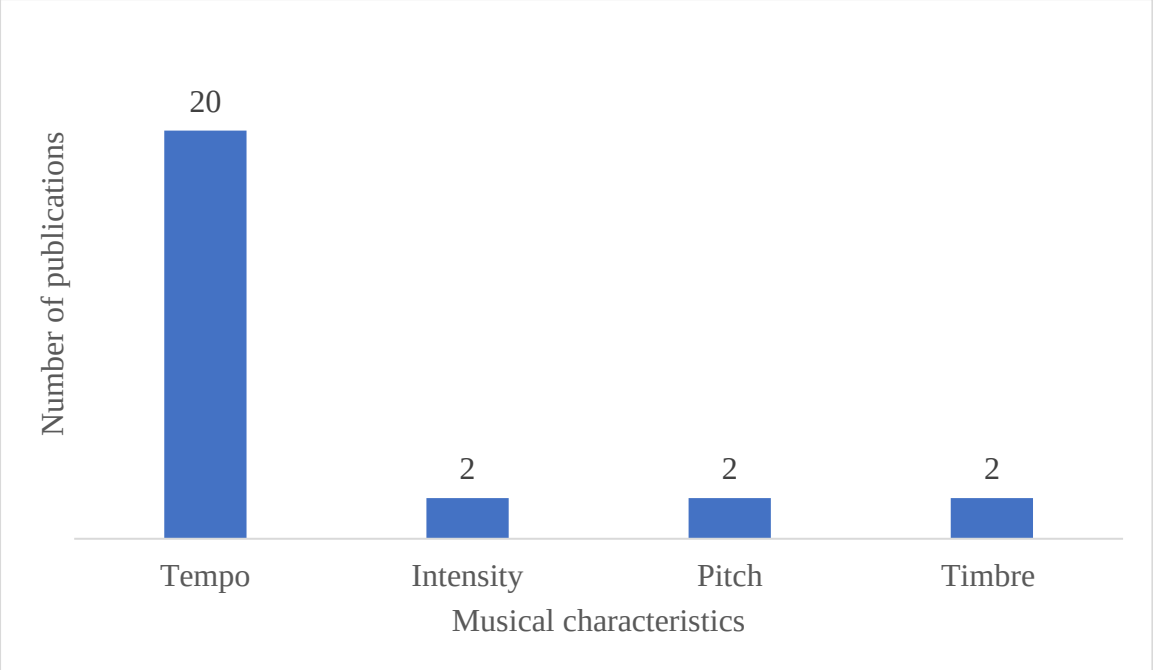
Music exists as an established treatment for various psychophysiological issues, these issues include anxiety and stress; which have been discussed in Chapter 2 (see 2.5.4.1. and 2.5.4.2). Different musical characteristics have been investigated, and consequently revealed to have certain positive effects on physiological and psychological correlates of anxiety and stress (Arjmand et al., 2017; Carpenter & Potter, 2007; Curtin, 2007; Crusius, 2018; Jiang et al., 2016; Lehrer, 2007; Mauss et al., 2003; O'Hagan, 2016; Stevenson et al., 2016)

When considering the research studies analysed within the current scoping review, it is concluded that tempo was the most frequent studied musical characteristic. Studies researching the effects of tempo account for 20 of the 21 included research studies. Where intensity, pitch

and timbre are concerned, two studies have been published for each individual characteristic, therefore amounting to six studies in total (Figure 4.8.).

Figure 4.7.

Number of publications investigating types of musical characteristics



4.3. Content analysis

As previously discussed (see 3.2.5.), a content analysis has been utilised in order to summarise and analyse the relevant data. The data was initially collected through a systematic search (see 3.2.3), whereby relevant articles and research studies were charted in a document. With the aim of assisting in the subsequent content analysis, a data extraction tool was utilised (Appendix D) to summarise and collate the data for analysis. Furthermore, certain criteria were selected with the goal to assist with the analysis (see Table 3.3.).

While music and its effects on psychophysiology have widely been studied, certain areas of investigation have become dated and limited in scope (Juslin et al., 2014). Evidence of the dated nature of the research is distinguished throughout the current scoping study. The scoping study also confirms that a small amount of research has been conducted over the scrutinised 12-year period. The limited scope of the research conducted within the 12-year period is evidenced throughout the scoping study. The scoping study further designates various inconsistencies and conflictions present within the research found regarding the current topic (Iakovides et al., 2004; Jacquet et al., 2014). The inconsistencies within the field, as mentioned by Iakovides et al. 2004 and Jacquet et al. 2014, is possibly due to the differing approaches and

objectives established within the included research studies. In an attempt to understand the origin of the conflicting results present within the content analysis, Table 4.2 summarises the primary objectives of the research studies included in this scoping review.

Table 4.2.

Authors and objectives

Author(s)	**Objective**
Chuen et al. (2016)	To investigate whether basic auditory changes often occurring during the act of listening of music can elicit changes in psychophysiological measures.
Kazymov et al. (2014)	To study the effects of medically resonant therapeutic music on healthy adolescents within a certain age group, as well as on adolescents with neurotic disorders within the same age group.
Kim et al. (2018)	To examine the impact of tempo matched to listeners' heart beats on cardiovascular- and affective responses during live performances to increase relaxation.
Shoda et al. (2016)	To investigate the differences in physiological responses to varying listening contexts, these contexts include; the context of live performances, as well as that of pre-recorded music.
Krabs et al. (2015)	To assess the effects of different musical tempos on ANS responses.
Ooishi et al. (2017)	To determine whether listening to music with a slow tempo or music with a fast tempo is accompanied by increases in the oxytocin and cortisol levels
Wang (2014)	To investigate the correlation between musical preference, musical expertise, and the degree of perceived relaxation when listening to music.
de Witte et al. (2019)	To summarize the growing body of empirical research within the field of music and psychophysiological responses.

Le Groux & Verchure (2012)	To validate the use of an automated synthetic music system to elicit emotional responses.
Tamaliunaite (2017)	To examine whether increases in tempo are related to increased subjective arousal and tonic pupillary responses. Additionally, to investigate whether percussiveness of the music moderates the relationship between tempo, subjective arousal, and tonic pupillary responses.
van der Zwaag et al. (2011)	To establish the impact of tempo, mode, and percussion on emotions.
Jacquet et al. (2014)	To assess the effect of pitch variations on self-reports regarding experienced valence and arousal.
Juslin et al. (2014)	To investigate the underlying mechanisms of emotional responses to music and investigate the presence of direct links between basic music characteristics and a listener's response.
Stith (2015)	To examine how different musical characteristics affect physiological responses.
Hernandez-Ruiz et al. (2020)	To understand which basic music characteristic most impacts the relaxation response.
Berger (2011)	To study whether tempo-based rhythm interventions can regulate and reduce repetitive anxiety in children with ASD.
Goldschmidt (2020)	To investigate changes in arousal due to planned tempo changes by utilising the Iso Principle.
Földes et al. (2017)	To determine whether music can reduce patient anxiety significantly while the patient is undergoing an MRI examination.
Brownlow (2017)	To assess the effect of musical tempo in reducing stress through psychophysiological measures.
Hunter et al. (2010)	To examine the similarities and differences between the perception of emotions conveyed through music, and listeners' emotional responses to the same musical pieces.

Tan et al. (2012)	To investigate the psychophysical characteristics associated with relaxing music, and to explore the correlation between; music familiarity, preference, and degree of perceived relaxation in music.

From the research studies included in the current scoping review, 15 studies focus primarily on the effects of musical characteristics on psychophysiological correlates. The remaining research studies focus on correlations between related responses to music, these correlations include; familiarity, preference, underlying mechanisms of responses to music, and perceived emotion. While taking into account the objectives of the included research studies, all research studies included in the scoping review have been found described below (see Table 4.2).

4.3.1. Discussion of the Content Analysis

Psychophysiology is the intersection of the mental and physical responses of the human body. Furthermore, psychophysiology considers how both responses function together, as well as how they influence each other (Cacioppo et al., 2007). Several research studies that have been included within the current scoping review investigated the psychophysiological impact of different musical characteristics on stress and anxiety. However, not all research studies included in the current scoping review investigated the effects of musical characteristics on *both* the psychological *and* physiological correlates of stress and anxiety. Numerous research studies focussed simply on investigating *either* the physiological response *or* the psychological response to basic musical characteristics. The discussion below explores each musical characteristic. These characteristics are first analysed according to the research studies investigating the psychophysiological aspects, followed by the studies focussing on the physiological aspects, and lastly according to the studies that focus on the psychological aspects.

4.3.1.1. Studies investigating psychophysiological responses to tempo

De Witte et al. (2019) conducted a meta-analysis exploring different ranges in tempo. De Witte et al. (2019) reason for the necessity of the meta-analysis by citing the availability of extensive research regarding the topic of stress reduction induced by musical intervention, thus warranting the synthesis of research. Regarding the studies included in this research, tempo was established as the only musical characteristic investigated. The studies conducted research

according to the most common tempo ranges used within the meta-analysis. The results of the meta-analysis found no significant moderating effect of tempo (between the range of 60-80 bpm and other ranges) on physiological correlates of stress (de Witte et al., 2019).

When considering the range 60-80 bpm, researchers found larger effect sizes evident within the psychological outcomes examined (de Witte et al., 2019). Unlike the physiological outcomes of stress investigated in the meta-analysis, where tempo illustrated no significant effect, tempo was found to influence the effectiveness of musical intervention on psychological outcomes. Tempo within the range of 60-80 bpm was found to represent calming, slow, and soothing music. This finding suggests that the range 60-80 bpm is possibly the optimal musical tempo to induce stress reduction (de Witte et al., 2019).

Utilising a similar tempo range, van der Zwaag et al. (2011) investigated the effects of tempo, percussiveness, and mode on psychophysiological parameters within an office setting by utilising 16 pop songs and 16 rock songs. A slow tempo was classified as 80 bpm, while a fast tempo was classified as 139 bpm, the two different tempos were incorporated into separate songs for the design. The songs were then played in the background while the participants had to complete a simulated office task (van der Zwaag et al., 2011).

The findings indicate that fast tempos result in a higher level of emotional arousal than that of slow tempos. While increased levels of arousal were linked to fast tempos, fast tempos were also linked to a higher reporting of positive valence when combined with high percussiveness (percussiveness being the characteristic of music that describes the sound texture of music) (van der Zwaag et al., 2011). When considering the results of increased tempos leading to a positive valence, these results cannot be attributed solely to the effects of tempo, as in this case, the effect was found to be a combination of tempo and percussiveness.

When considering the physiological measurements mentioned in van der Zwaag et al.'s (2011) research, a greater number of SCRs were observed in a fast tempo condition when compared to the conditions of other musical characteristics. The SCR result is congruent with the higher levels of emotional arousal indicated in the faster tempo condition. Additionally, when tempo had been considered, statistically significant results had been found. The results found HRV to be a more significant main effect when compared to the other musical characteristics (van der Zwaag et al., 2011). Ultimately, a decrease in HRV was found with the introduction of an increased tempo, which was then accompanied by increased reports of anxiousness experienced.

Krabs et al. (2015) also explored the relationship between tempo and its subsequent psychophysiological responses. The research defined a slow condition as 90 bpm and a fast

condition as 120 bpm. Krabs et al. (2015) conducted two experiments focusing on the autonomic effects of music. The second experiment, which is the focus of this discussion, investigated the effects of different tempo changes on HR, HRV and emotional valence. Four classifications of tempo were used, each classification corresponding with a specific bpm. The following classifications were employed; (1) a slow and pleasant type of music with 90 bpm, (2) a fast and pleasant type music with 120 bpm, (3) a slow and unpleasant type of music with 90 bpm, and (4) a fast and unpleasant type of music with 120 bpm.

Furthermore, no differences were found between the musical classifications when valence was regarded. Due to the lack of change observed regarding emotional valence, Krabs et al. (2015) suggest that the research study in question provides an objective insight into the effect that different tempos have on autonomic responses. When comparing the observed autonomic responses to those present during a period of silence, all musical classification conditions were found to elicit a response in HR and HRV, although the responses were not classified as statistically significant. In comparison to conditions of silence, each musical classification exhibited a marginal increase in HR. Notably, there were no differences in the changes that HR elicited regarding the introduction of different tempos. Furthermore, HRV showed a marginal decrease in most parameters, with no observed differences between the music classification types (Krabs et al., 2015). The results of the research study performed by Krabs et al. (2015) suggest that tempo does not have an effect autonomic responses, thus unearthing a further contradiction in the relevant research.

While not fully comparable with the results found by Krabs et al. (2015) due to the differing tempo ranges utilised within each study, Hernandez-Ruiz et al. (2020) found conflicting results when considering SCL and SCR. As a guide for the musical characteristics, Hernandez-Ruiz et al. (2020) used Hanson-Abromeit's (2015) TFM Plan to structure the experimental conditions. Thus, the standard tempo in the study was set at 65 bpm and was further decreased to 45 bpm for the actual tempo condition.

When considering the SCL measurement, two distinct groups showed opposite results, which was unexpected by Hernandez-Ruiz et al. (2020). The first conflict present within the results was that 60% of the first sample had a lower SCL for most of the conditions, while the 40% of the second sample showed no changes in SCL. Further results indicated that, while no statistical significance had been found, mean measurements of relationship were in line with what the researchers had predicted, the prediction being that a bpm of 45 would lower the physiological measurements. While the lowering effect of certain tempos on SCL mirror the

results found by Chuen et al. (2016); SCL decreases were found in most of the conditions tested by Hernandez-Ruiz et al. (2020), with a clear divide in sample effects.

Considering the psychological results found by Hernandez-Ruiz et al. (2020), tempo showed a strong positive relationship with emotional arousal and valence (the research study in question having aligned valence with the experience of participant enjoyment). Furthermore, the results indicated that an increase in excitement and arousal experienced by participants, led to an increase in participants' enjoyment of the music (Hernandez-Ruiz et al., 2020).

4.3.1.2. Studies investigating physiological responses to tempo

The research study conducted by Chuen et al. (2016), found during the preliminary search for literature in the current scoping study, addressed the effect of tempo on physiological responses. The researchers investigated changes in pitch, duration, timbre, and intensity by deviating from an isochronous tone, an isochronous tone being a tone occurring at equal time intervals. The researchers utilised 144 different sound conditions, the sequences were established at 15 seconds in duration and commonly presented at a tempo of 100 bpm. The sound conditions were set to vary from no changes, changes in pitch, changes in timbre, to changes in tempo (Chuen et al., 2016).

Variations in tempo were measured in ranges in order to allow for the observation of discernible auditory changes. The changes included conditions with; 80 bpm, 100 bpm, 120 bpm, and 150 bpm. It was found that increases in tempo caused changes in HR and SCR, which were both proportional in nature. No changes were discovered regarding the effect of tempo on RR (Chuen et al., 2016).

Taking a different approach to understanding the impact of tempo, Brownlow (2017) investigated the effects of tempo on the stress response, specifically the effects on HR and EDA. Brownlow's (2017) research differentiated between three tempo groups, these groups including; one group including a song with a fast tempo, another including a song with a slow tempo, and the last group composed of silence. The song 'Nuvole Bianche' by Ludovico Einaudi was used and manipulated into the fast and slow tempo condition. Brownlow (2017) took an extreme approach to tempo manipulation, by changing the song tempo from 120 bpm for the designated slow condition to 300 bpm for the fast condition. As mentioned by Schmidt-Jones (2003), a bpm of 120 is already considered fast, therefore proving that the conditions introduced by Bronlow (2017) constitute an extreme approach to testing tempo.

HR was affected by all conditions and increased significantly when participants listened to the fast tempo music, while the opposite was true for the introduction of slow tempo music.

Absence of sound also decreased HR, however; not as much as the slow tempo music condition. The results regarding the effects of tempo on HR suggest that faster paced music increases physiological arousal, while slower paced music has a greater potential to reduce physiological arousal than silence (Brownlow, 2017).

Much like the results found regarding HR, EDA also increased during the fast tempo condition, therefore also suggesting an increase in sweat, and consequently an increase in arousal. The result of an increased EDA was also found in the silence condition, which is contrary to the assumption that slow tempos and an absence of tempos decreases physiological stress responses. While researchers suggest that the contrary result is possibly due to stress or anxiety from wearing earplugs for the silent condition, therefore indicating further evidence of contradictory research within the field. Further contradictions are evident when considering the lack of autonomic response found in the research study conducted by Krabs et al. (2015).

Furthermore, EDA also increased across all three conditions (Brownlow, 2017). It should be considered that Brownlow (2017) did take an extreme approach to tempo ranges, further substantiating that inconsistent tempo ranges utilised within the various research studies cause contradictory research scenarios. Further contradictions were also found when considering autonomic responses to tempo, such as in a research study conducted by Stith (2015). Stith (2015) hypothesised that faster tempos would result in higher arousal than that of slower tempos, and that slower tempos would not have an arousing effect. Fast tempos were set at 90 bpm and slow tempos at 60 bpm, falling within the suggested range of Witte et al. (2019) (Stith, 2015).

The research study conducted by Stith (2015) found no physiological response (HRV and HR) to tempo. Additionally, Stith (2015) found no evidence of a relationship between tempo and emotional valence. Stith (2015) theorised that the lack of physiological response could be attributed to the range of tempo, which was lower than comparable studies. The lower bpm for fast tempo songs can be attributed to the lack of change, as it is evident that 120 bpm is considered fast, while 90 bpm is considered midrange (Schmidt-Jones, 2003).

4.3.1.3. Studies investigating psychological responses to tempo

The above results are suggestive of a relationship between emotional arousal and valence, as was also considered in Tamaliunaite's (2017) research. Tamaliunaite (2017) investigated self-reported emotional arousal and valence in response to changes in the tempo of musical excerpts. Participants were exposed to musical excerpts while completing the Stroop Test to simulate a stressful task. Consistent with the previous findings of Kellaris and Kent

(1991), as well as that of Husain et al. (2002), higher tempos of 140 bpm resulted in greater reported arousal, while lower tempos of 80 bpm resulted in lower levels of arousal. Similarly, reports on valence were also impacted by changes in tempo. It was found that increased tempos resulted in an increased valence rating, with a bpm of 140 being rated the most pleasant. In terms of higher tempos increasing emotional arousal and valence, Tamaliunaite's (2017) results are congruent with the findings of Hernandez-Ruiz et al. (2020) and van der Zwaag et al. (2011). Furthermore, the findings of van der Zwaag et al. (2011), combined with that of Chuen et al. (2016), Hernandez-Ruiz et al. (2020), and Tamaliunaite (2017) suggest that tempo regulates emotions. These findings consequently indicate that tempo can be utilised to direct emotion.

In line with the suggestion that tempo can direct emotion, Tan et al. (2012) considered the relationship between musical preference and familiarity, as well as the psychological properties that define relaxing music. The research consisted of three parts, with the first and second parts including the participation music therapists. The music therapists rated the musical selections according to the degree of relaxation. Musical selections with a rating of five and lower were excluded from the third part of the study. Based on the selections established by the music therapists in the first and second part of the study, the final part of the study investigated the validity of the previous studies' results. Participants rated preference, familiarity, and degree of relaxation for each selection, with each selection lasting a total of 30 seconds (Tan et al., 2012).

For the purpose of the current research study, only the results relating to the ratings found within the degree of relaxation will be considered. When considering the ratings in conjunction with the musical selections, Tan et al. (2012) suggested that the optimum tempo for relaxation is 60 bpm, which is also corroborated by de Witte et al. (2019). Ultimately, the research study conducted by Tan et al. (2012) found a negative correlation between tempo and degree of relaxation. This corresponds with Wang's (2014) findings, which indicated that a decreased tempo resulted in increased feelings of relaxation. It further corresponds with the findings of Tamaliunaite (2017), Hernandez-Ruiz et al. (2020) and van der Zwaag et al. (2011); which all indicated that an increase in tempo caused increased emotional arousal. While there exists certain corresponding areas within the current field of research, contradictions and conflicting results are evident when considering the research conducted by Le Groux and Verchure (2012).

The primary focus of the study conducted by Le Groux and Verchure (2012) explored the usage of synthetic musical systems in generating expressive musical pieces utilising

different musical characteristics. As a secondary focus, the researchers investigated the effect of the musical characteristics on emotional responses, particularly; its effect on emotional valence, arousal, and dominance. Tempo formed the key focus of the study, with 27 sample sounds consisting of bpm's ranging between 50-200 bpm in an automated synthetic music system. The method involved participants being exposed to various listening conditions, and was then followed by participants reflecting upon ratings regarding valence, arousal, and dominance (Le Groux & Verchure, 2012).

The results indicated that a musical sound with a higher tempo resulted in greater emotional arousal in the participants. Additionally, researcher identified an associated negative valence with higher tempos than with slower tempos (Le Groux & Verchure, 2012). Additionally, Ooishi et al. (2017) also found that slow tempos were accompanied by a higher positive valence. The previous findings are in contrast with those established by Tamaliunaite (2017) that indicated that increased tempos resulted in positive valence. Tamaliunaite (2017) suggested that any confliction in results may be due to the concurrent execution of the Stroop Test in the study while participants were listening to the same musical excerpt (with varying tempo). Tamaliunaite (2017) also indicated that boredom might have played a role, thus suggesting that the context in which music is listened to is also important when analysing ratings of pleasantness (Juslin & Västfjäll, 2008). Consequently, it is evident that the available research regarding changes in tempo and its subsequent effect on valence is conflicting in nature.

There are also research studies, such as that conducted by Kazymov et al. (2014), that do not specify the exact bpm of the musical intervention, and merely include vague descriptions of 'fast' and 'slow' tempos. The objective of Kazymov et al.'s (2014) research was to examine the effects of medical resonance therapeutic music (MRTM) on the psychological correlates of healthy adolescents, as well as that of adolescents with neurotic disorder (generalised anxiety disorder and adjustment disorder). MRTM has also been established to own a high potential for music therapy; it has been determined that music resonance at a frequency between 0.034 to 5 Hz is most beneficial when played for 20 minutes, through headphones, in an undisturbed environment, for multiple times a day (Ernest, 2013).

Kazymov et al. (2014) took the previous findings into consideration and combined it with further research studies, each suggesting that the efficacy of music therapy is dependent on various factors, these factors include; tempo, age, personality, genre, and music content. By allowing participants to rate the extent of emotional pleasantness of musical segments, the researchers established subjective preference to be a core aspect of the research design.

Furthermore, anxiety STAI and wellbeing (further referred to as WAM) levels were measured both before and after the MRTM.

While the results did investigate psychological correlates, not all parameters were directly linked to musical characteristics. Kazymov et al. (2014) found that adolescents between the ages of 15 and 16 (regarding both the healthy and neurotic condition), preferred faster musical compositions. Regarding adolescents that fall within the previously mentioned age range, those in the health condition also exhibited a reduction in situational anxiety, as well as positive emotions, further indicating the presence of a sedative effect regarding faster tempo compositions. Interestingly, the opposite was true for those with the neurotic condition, which experienced a heightened experience of anxiety.

Older age ranges (17-18 years), both in the healthy and neurotic condition, also preferred faster and distinct tempos, and experienced a decrease in situational anxiety as well. Kazymov et al. (2014) consider the preference of the faster tempo for the neurotic condition to indicate that the music chosen by participants could be reliant on a match in the negative emotional and anxious feelings experienced by the participants, and the perceived musical emotion of negativity. The relationship between perceived and felt emotions was further investigated by Hunter et al. (2010).

Hunter et al. (2010) investigated the effect of slow tempo ranges (41-87 bpm) and fast tempo ranges (82-174 bpm) on emotional arousal. Importantly, Hunter et al. (2010) distinguished between felt and perceived emotions through using ratings of the musical interventions used in the research design. Felt emotions were defined according to how the participant felt emotionally while listening to the music, whereas perceived emotions were defined as the recognisable emotions that were conveyed through the music (Hunter et al., 2010).

The present study focuses on felt emotion rather than perceived emotion, (see Table 3.1. for exclusion criteria), therefore, the discussion considers the results of tempo in relation to felt emotional arousal rather than perceived emotion. Hunter et al. (2010) found that reported happiness significantly corresponded to faster tempos, and sadness to slower tempos. Although, this interaction was significant, the ratings for perceived emotions were stronger than those of felt emotions. Additionally, participants were allowed to provide mixed happy and sad ratings for felt emotions. It was further found that slow tempos provided more mixed ratings than fast tempos (Hunter et al., 2010).

While the current research study focuses solely on the results pertaining to felt emotions, it is noteworthy to acknowledge the full conclusions of the researchers. In their

conclusions, Hunter et al. (2010) considered the relationship between perceived and felt emotions. Hunter et al. (2010) postulated that perceived and felt emotions in music are correlated, however; they are not identical. The researchers further suggest that a listeners' feelings when listening to music is affected by their perception, which is further impacted by musical cues. In this case, tempo manipulation had a heightened effect on sadness and happiness (Hunter et al., 2010). Song et al. (2016) found similar results in a research study, the results indicated that evoked emotions from music resulted in similar perceived emotions of said music.

Juslin et al. (2014) took a different approach when attempting to understand the psychological effects of music. The researchers set out to establish the 'why' behind emotional arousal. The goal was achieved by considering the underlying mechanisms that are stimulated by different musical elements. Juslin et al. (2014) focused on four facets, the facets including; brain stem reflex, episodic memory, music expectancy, and emotional arousal. However, for the purposes of the present study, only the latter aspect will be considered as it aligns with the research question.

Participants rated felt emotions according to a twelve level 12. The scales were established according to descriptions of basic and discrete emotions that had been most commonly used in similar studies (Juslin et al., 2014). These scales are tabulated below (Table 4.3.).

Table 4.3.

Felt emotion scales as per Juslin et al.'s (2014) study

Felt emotion scale
Happiness-elation
Sadness-melancholy
Surprise-astonishment
Calm-contentment
Anger-irritation
Nostalgia-longing
Interest-expectancy
Anxiety-nervousness
Love-tenderness
Disgust-contempt

Admiration-awe
Pride-confidence

In Juslin et al.'s (2014) study, the effect that tempo had on various mechanism was considered, these mechanisms included; brain stem reflex, episodic memory, music expectancy, and emotional arousal. The subsequent results contradicted the results found by more common approaches, namely; that *slow* tempo music tends to evoke calmness or sadness. Juslin et al.'s (2014) findings rather indicated that music with a *fast* tempo is linked to sadness, rather than surprise or happiness. The researchers postulated that the contradiction in findings was most likely due to the underlying mechanisms at play, such as; musical expectancy or episodic memory evocation (Juslin et al., 2014). In conclusion, Juslin et al. (2014) state that a surface level approach of musical characteristics and its subsequent effects might not provide a complete picture. The above suggestion by Juslin et al. (2014) relates to researchers' previous propositions that music preference, familiarity, listening context, and the relationship between felt and perceived emotion most likely interplay with psychological responses to music (Hunter et al., 2010; Shoda et al., 2016; Tan et al., 2012).

When reviewing the above research on tempo, it is evident that the varying methods used in the research studies resulted in variations regarding the results obtained. The classification of 'fast' and 'slow' tempos become incomparable with one another due to the great differences in the beats per minute utilised by the researchers mentioned above. While there exists a large range of utilised tempos, the range most commonly agreed to induce relaxation is that of 60-80 bpm; which is in line with the suggestion by de Witte et al. (2019) that 60-80 bpm should be considered the optimal range for reducing psychological stress.

Considering the psychological effects of tempo, most researchers agree that an increase in tempo causes a subsequent increase in emotional arousal. However, the effect of tempo on valence was not as clearly established. Some studies indicated that increased tempos are linked to *positive* valence (Hernandez-Ruiz, 2020; Tamaliunaite, 2017), while others provided evidence that increased tempos are rather linked to *negative* valence (Le Groux & Verchure, 2012; Tamaliunaite, 2017; van der Zwaag et al., 2011). As mentioned previously, the conflicting results could be attributed to the differing ranges in tempos utilised within the research studies. Furthermore, the previous notion can be applied to the results concerning the physiological effects of tempo as well. Conflicting results were often found between the various research results, with no statistical significance being established to indicate whether

there indeed exists a tangible relationship (Juslin et al., 2014; Krabs et al., 2015; Chuen et al., 2016). Through analysing the small scope of research reviewed, it is evident that there exists many focal points for possible new research.

4.3.1.4. Studies investigating psychophysiological responses to intensity

Alongside the exploration of the impact of tempo, Hernandez-Ruiz et al. (2020) also considered the impact of intensity on psychophysiological responses by experimenting with a range of -10 dB to 55 dB. The researchers hypothesised that an intensity level of -10 dB would lower all psychophysiological measures investigated within the study. Regarding the researchers' hypothesised measurements in musical characteristics, the greatest change was observed with HR and SCL, which displayed the biggest decrease for the intensity condition. Regarding the findings of Chuen et al. (2016), there were no observed changes with RR regarding the intensity condition (-10dB). Albeit that the intensity condition indicated a great change, it was not statistically significant. The results suggest that no single musical characteristic significantly reduced the psychophysiological correlates of stress or anxiety, however; that the musical composition might have been composed in such a manner as to induce relaxation (Hernandez-Ruiz et al., 2020).

Additionally, Hernandez-Ruiz et al. (2020) also presumed that the self-reports for arousal and valence would correspond with the psychophysiological measures taken, however; no significant correlation was found between the self-reports and physiological measurements. There exists the possibility that physiological correlates of stress and anxiety do not hold a direct correspondence with experienced emotional arousal (Hernandez-Ruiz et al., 2020).

4.3.1.5. Studies investigating physiological responses to intensity

As discussed in Chapter 2 (see 2.5.3.3.), intensity is often utilised within a musical composition to affect the mood of the listener. Unlike tempo, intensity was not increasingly studied over the 12 year period, however; Chuen et al. (2016) did investigate the effect of changes in intensity on physiological responses. Much like tempo, discernible volumes were chosen as variations within the sound conditions. Four intensity levels were included, namely; 65 dB, 70 dB, 75 dB, and 80 dB. These intensity levels were incrementally increased by 10 dB and 15 dB (Chuen et al., 2016).

Similar to the response elicited by changes in tempo, an increase in intensity also caused an increase in SCR, with these increases proportional to the change in intensity (Chuen et al., 2016). No changes had been observed for RR. Furthermore, fluctuations in HR were found to

be connected to changes in intensity. The intensity had been increased by 10 dB, which subsequently caused a decrease in HR, and was then followed by an increase in HR. Notably, a change from 10 dB to 15 dB caused an *overall* increase in HR, therefore including none of the fluctuations that had been present within the 10 dB condition (Chuen et al., 2016). The initial deceleration of HR is indicative of an orienting response to smaller changes in intensity. The orienting response describes responsive adaptive behaviour that is automatic to changes in the environment. One of these changes includes variations in sound, therefore leading to the conclusion that miniscule changes in musical characteristics have the possibility to cause the appropriate physiological responses (Berti et al., 2017; Chuen et al., 2016).

While there is a clear lack of literature considering the effects of intensity; through examining the previous two research studies, it has become evident that researchers have utilised differing ranges in intensity. The lack of consistency within the research studies lead to the impossibility of reviewing the research as comparable. Furthermore, it causes conflictions within the literature, and warrants further investigation.

4.3.1.6. Studies investigating psychophysiological responses to timbre

Regarding timbre, it has been investigated in a limited manner, with the only researchers focusing on a psychophysiological perspective being Hernandez-Ruiz et al. (2020). The design of the research study performed by Hernandez-Ruiz et al. (2020) has been discussed previously (see 4.3.1.1). A mellow timbre was adopted utilising a bass clarinet, and was further opposed by a piercing trumpet timbre. Similar to the previous results regarding tempo, researchers found no significant changes caused by timbre. Informed by findings from previous studies, Hernandez-Ruiz et al. (2020) had conjectured that the mellow timbre of a bass clarinet would lower all physiological measures investigated in the study, however; when considering arousal and positive emotions, timbre had been *positively* correlated to the physiological aspects investigated. Furthermore, similar to the previous findings, the piercing timber from a trumpet was found to increase emotional arousal and positive emotions as well. The above findings therefore opposed the researchers' hypotheses; the hypothesis being that a piercing timbre would be related to negative emotions rather than positive emotions (Hernandez-Ruiz et al., 2020).

4.3.1.7. Studies investigating physiological responses to timbre

As discussed in 4.3.1., Chuen et al. (2016) had considered the autonomic responses to timbre when a deviation in sound from a standard isochronous noise was introduced. Regarding

the 144 sound conditions, 25% had no change in timbre, while the other 75% was equally divided into; changes in the timbre of a trumpet-like tone, changes in a French horn tone, and changes in an obochord tone (an obochord being the combined sound of an oboe and a harpsichord). The research therefore focused on the effects of timbre resulting from; woodwind instruments, keyboard instruments, and brass instruments (Chuen et al., 2016).

It was found that all the fluctuations in timbre resulted in subsequent changes is SCR and HR responses, however; no changes were observed regarding RR. Continued analysis illustrated gradual, yet significant, effects in HR. Regarding the different instruments, HR was observed to increase for all of the three conditions, however; it is important to note the presence of a deceleration in HR *before* the acceleration for the trumpet and obochord condition (Chuen et al., 2016). The previous observation is similar to that of intensity; whereby deceleration and acceleration in HR was observed as well. The distinguished pattern of timbre is indicative of an orienting response to certain instruments, or rather, to the manner in which an instrument is played. Furthermore, much like the changes in HR, timbre caused significant effects in SCR as well. Upon further investigation, the trumpet condition elicited the greatest change from SCR, while the bassoon condition (isochronous sound) elicited a smaller response (Chuen et al., 2016).

When analysing research on timbre, recent work is limited. However, by analysing the included studies, it can be established that researchers prefer investigating the effects of wind instruments, such as; horns, trumpets, and bassoons (Chuen et al., 2016; Hernandez-Ruiz et al., 2020). Furthermore, certain results will require further investigation, these results include; the possible orienting response found in the research executed by Chuen et al. (2016), as well as the result concluded upon by Hernandez-Ruiz et al. (2020) that piercing trumpet timbres increase positive emotions.

4.3.1.8. Studies investigating physiological responses to pitch

While analysing the research published during the time period established for the current scoping study, it was established that pitch had not been a focal point for many research studies. Considering the lack of research, Chuen et al. (2016) investigated the influence of pitch on physiological aspects, as discussed above (see 4.3.1.). The sound conditions were broken up into quarters, with one condition producing no change in pitch, while the other three conditions were set at 392 Hz, 494 Hz, and 659 Hz respectively (Chuen et al., 2016). In Cheun et al.'s (2016) research, pitch affected HR; HR decreased when there were no changes in pitch,

and increased for higher pitches. Furthermore, no changes in SCR and RR were recorded within the differing pitch conditions.

4.3.1.9. Studies investigating psychological responses to pitch

Jacquet et al. (2014) investigated three different pitch levels, these levels included; one octave (440 Hz) lower than the researcher's original musical composition, the original composition, and one octave higher than the original composition. The researchers investigated these three levels in relation to the various effects produced in emotional arousal and valence. In the condition that lowered the octave of the musical composition, felt pleasantness decreased significantly. Differences between genders were also observed in the research study, with women participants experiencing a stronger decrease in felt pleasantness than men participants. Furthermore, men experienced higher level of arousal for the higher pitch conditions than women. Ultimately, Jacquet et al. (2014) concluded that a negative relationship between pitch and emotional arousal levels does indeed exist, and is further moderated by gender.

Much like with the research on intensity and timbre, there exists a limited amount of current research on pitch, therefore indicating a research gap. Notably, the two available studies regarding pitch contain a core contradiction. The research by Chuen et al. (2016) suggests a positive relationship between pitch and HR, whereas the research conducted by Jacquet et al. (2014) suggests a negative relationship between emotional arousal and pitch. While physiological arousal (HR) and emotional arousal are not automatically linked, each are common elements of stress and anxiety (Du et al., 2018; Croft et al., 2004). The findings of the research studies by Chuen et al. (2016) and Jacquet et al. (2014) invites further investigation.

4.3.2. Tempo entrainment

When considering the above research studies, it becomes evident that the current research topic is of a complex nature. The complexity being due to a lack of complete understanding regarding all the variables involved, as well as of their relationship with one another (physiological, psychological, contextual etc.) (Iakovides et al., 2004; Juslin et al., 2014). While reviewing the included studies, a theme of entrainment became apparent, therefore conflicting with the suggestion that basic musical characteristics do not provide a complete picture of psychophysiological responses to music. Tempo entrainment is the synchronisation of internal physiology with an external musical beat. The sections below discusses research studies included in the current scoping review that address the process of tempo entrainment.

4.3.2.1. Studies investigating tempo entrainment and psychophysiological correlates of stress and anxiety

Tempo entrainment has been investigated as a facet of the 'Iso Principle'. The principle states that musical characteristics have the possibility to meet a listeners' internal physiological state, and that adjustments to said musical characteristics will lead the physiological state in the same direction (Heiderscheit & Madson, 2015). Goldschmidt (2020) investigated the Iso Principle by considering its effect on emotional arousal and EDA. The research utilised two conditions for the experiment, namely; (1) the Iso Principle condition initially played at 60 bpm and then ascended to 120 bpm, and (2) the control condition whereby participants listened to a short story. When considering EDA responses, the Iso Principle condition showcased various peaks in data when compared to the control condition, therefore suggesting that emotional intensity increased along with an increases in tempo. Self-assessments of arousal using the SAM (valence, arousal and dominance) test corresponded to the changes in EDA when compared to the control condition, however; these changes were not statistically significant (Goldschmidt, 2020).

4.3.2.2. Studies investigating tempo entrainment and physiological correlates of stress and anxiety

Tempo entrainment was investigated by Kim et al. (2018) in terms of its impact on HR as a physiological response. 30 participants partook in the study, being assigned to either the experimental group or the control group. The control group listened to music at a fixed tempo, while the experimental group listened to a tempo where live music was played to match the participants' HR, after a stress task was administered. The tempo was gradually decreased to induce a relaxation effect in the experimental group, which is a strategy employed frequently in music therapy (Kim et al., 2018). The researchers found that HR increased after the stress task, however; there was no significant difference between the experimental group and control group (with the tempo staying constant at 70 bpm). While HR was not significantly affected by the constant reduction in tempo, self-reported stress increased drastically, therefore indicating a stress-reducing effect resulting from tempo entrainment (Kim et al., 2018).

4.3.2.3. Studies investigating tempo entrainment and psychological correlates of stress and anxiety

Synchronisation and entrainment of musical characteristics appears to be a growing area of interest. An example being Földes et al. (2017) examining the effects of synchronised

music on MRI gradient pulsation sounds to quell anxious and claustrophobic responses. The study included two experimental groups, namely; one random musical group that listened to songs in their original tempo, and a second synchronous group, that listened to songs with a manipulated tempo that matched the sounds of the MRI machine. Participants were tested on their levels of anxiety and feelings of pleasantness (measured by the STAI and VAS respectively), with a control group that did not listen to music also being included (Főldes et al., 2017). The results found that both music groups experienced significantly lowered state anxiety when compared to the control group that did not listen to music. Additionally, the reported feelings of pleasantness for the overall MRI experience were more pleasant for the musical experimental groups than for the control group. When comparing both music groups, no significant statistical differences were found in State Anxiety levels. While there existed no significant difference in State Anxiety levels, the synchronous group with an altered tempo had lower state anxiety scores and higher ratings of pleasantness regarding the experience than the random music group. Főldes et al. (2017) theorised that the lack of statistical significance could be due to the relatively low sample size (n=60), the changing gradient pulsation of the MRI machine, or the manual tempo manipulation of the sounds. Overall, the research study indicated that listening to music during an MRI examination can reduce anxiety levels and increase the pleasantness of the overall experience (Főldes et al., 2017).

In another research study based on the entrainment principle, a pilot study was conducted to determine the effect of a tempo-specific rhythm intervention on children with Autism Spectrum Disorder (ASD) (Berger, 2011). Tempo was set at a slow pace of 60 bpm with highly structured tempo interventions. The effects of these interventions were studied in terms of common ASD behaviours, these behaviours included; systematic pacing, visual contact, motor planning, reduction of anxiety, repetitive behaviours, and attention. HR was measured for three of the sessions as well (Berger, 2011). Regarding the research conducted by Berger (2011), participants were not passive listeners, rather, participants completed various tasks, one of these tasks included marching and clapping to the 60 bpm tempo intervention played on a keyboard. Controlled arousal (or entrainment) were key elements considered in the research, and were clearly illustrated as affected by the interventions. Ultimately, the research established that physiological function changed along with tempo intervention, as HR returned back to baseline measurement during the rest periods (Berger, 2011). When considering the research on tempo, a range between 60-80 bpm corresponds with the optimal range for relaxation, and further corresponds with the pace of the average resting HR (Steelman, 1991; de Witte et al., 2019).

4.5. Conclusion

This chapter discussed the results of the current scoping study, which found 21 publications that fit the inclusion and exclusion criteria. Most of the publications were released between 2014 and 2017, and include a heavy focus on tempo as a musical characteristic. The review also established HR as the most studied physiological correlate, and emotional arousal and valence as the most common psychological correlates. By reviewing the included research studies' objectives, it has become evident that the presence of varying aims in research has influenced the methods undertaken to achieve an understanding of the psychophysiological correlates of stress and anxiety and music. The inconsistency in approaches has resulted in varying descriptions and ranges regarding musical characteristics, and could be a contributing factor to the conflicting research present within the field. Chapter 5 will address will include further suggestions relating to the results of this chapter.

CHAPTER 5: CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

5.1. Introduction

Chapter 5 firstly provides an overview of the results of the current scoping study. Munn et al. (2018) mentions that scoping studies are still considered a relatively new form of review utilised in research, therefore there are, clear limitations of the methodology. This chapter thus addresses and methodological limitations, as well as any additional limitations of the present research study. Chapter 5 also highlights key research gaps and related recommendations for future research, based on the results of Chapter 4. Lastly, the current chapter draws a final conclusion from the current scoping review.

5.3. Conclusions of the current research study

The present research study utilised an adapted scoping review method by Arskey and O'Malley (2005) and Levac et al. (2010) to address the aim and objectives of the research. A total of 21 research studies were identified and included in the current scoping review. Linking back to the aim of the current research study, the amount of literature identified indicates that there is a general research gap due to the lack of recent research studies within the field (over a 12 year span).

Research gaps in terms of participant characteristics were evident, with there being less research studies conducted on males and various ages and ranges. The numerical results showed that ages within the 20s was more commonly studied than younger ages within the child and adolescent range, as well as older ages over 30. Further considering participant characteristics, most research studies included in the present scoping review were conducted with population from U.S.A., while no studies were found to have been conducted with a South African population. When considering the psychophysiological correlates of stress and anxiety, RR was the least researched physiological response. Similarly, there were less studies that investigated SCL/SCR and HRV responses. The numerical results also show that anxiety and stress (measured through psychometric tests) and perceived relaxation were not commonly studied in recent research. Lastly, when considering the numerical results, tempo was the most common studied musical characteristic. The scope of research studying intensity, pitch and timbre is limited in nature.

The content analysis (see 4.3.) revealed that there are contradictions in the responses elicited psychophysiologically to a single music characteristic. It is often found that results are incomparable or contradictory due to the operational definitions used in different research

studies. Considering the research studies included that investigated the effects of tempo, this point is especially relevant across all psychophysiological, physiological and psychological correlates investigated. Looking at the definitions of 'slow' and 'fast' tempos used by van der Zwaag et al. (2011), Krabs et al. (2015), Brownlow (2017), Stith (2015), Kazymov et al. (2014), Hunter et al. (2010), and Juslin et al. (2014), these vary in bpm. Furthermore, musical characteristics in isolation were not always considered, thereby the effect on the psychophysiological correlates of anxiety and stress could not be solely attributed to a single characteristic (tempo and percussiveness was explored together in van der Zwaag et al.'s (2011) study).

Looking at the musical characteristics investigated, tempo had the greatest effect on psychophysiological correlates of anxiety and stress, which may be due to the musical characteristic being the most studied. However, conclusions can be made in terms of corresponding results in the included research studies. Physiologically, the range of 60-80 bpm corresponds to a resting HR, which makes treatments using this tempo promising for reducing anxiety and stress. A 60-80 bpm also relates to the concept of tempo entrainment, which suggests that the synchronisation of physiological responses of a tempo matching resting HR can treat anxiety and stress (Főldes et al. 2017; Goldschmidt, 2020; Kim et al., 2018; Stith, 2015; Witte et al, 2019).

Taking a psychological perspective, generally an increased tempo resulted in an increased emotional arousal. An elevated emotional arousal from fast tempos indicated that tempo regulates emotion and can consequently be used to direct emotion during musical treatment or intervention (Hernandez-Ruiz et al., 2020; Tamaliunaite, 2017; van der Zwaag et al., 2011).

When considering the other investigated musical characteristics (intensity, pitch, and timbre), definitive conclusions on the effect of the characteristics are difficult to make due to the limited recent literature. Responses due to these musical characteristics are evident (Chuen et al., 2016; Hernandez et al., 2020) however, contradictions do exist thereby necessitating future exploration (Chuen et al., 2016; Jacquet et al., 2014).

The conclusion drawn from the present scoping review indicate that treatment through the use of basic auditory and musical characteristics to reduce stress and anxiety is a promising avenue of intervention. Further research is necessary to explore the effectiveness of different music characteristics, as well as to find corresponding and non-contradictory results.

5.2. Limitations of the study

A limitation of the current research study is that only studies written in English were reviewed during the process. Only English studies were selected because the researcher was solely fluent in the language, however it is notable that there may be studies covering the research topic not in English.

While rigor was an adaptation to Arksey and O'Malley's (2002) scoping review approach, a possible limitation could be human error. Human error during the title, abstract review and study selection was a possibility as there was no research team for the current research study to counter review, as Levac et al. (2010) suggested. While this limitation was addressed in the rigor discussion of Chapter 3 (see 3.2.6.), there was still a chance of human error during selection.

A further limitation could be linked to the methodological design of scoping reviews, as explained by Tricco et al. (2016). Scoping reviews do not include an appraisal of quality when research studies are selected for inclusion. The lack of quality appraisal is in the nature of scoping reviews as the objective is to map the breadth of information available. Thus the thematic description may not be a valid and reliable summarisation of existing literature results.

Another limitation of the current research study could be the exclusion criteria, which may have limited the scope of the literature. The current study took into consideration the suggestions and comments of Coutinho (2011). Coutinho (2011) suggested lower level music characteristics (timbre, tempo, intensity and pitch) should be investigated further as complexities between emotions and music characteristics seemingly exist. Couthino's (2011) suggestion was utilised in the present rationale of the research, however it is possible that the consideration of other music characteristics (mode, percussiveness, key etc.) would have provided more scope and literature to be included in the review.

5.4. Recommendations for future research

A recommendation for future scoping studies is to follow Levac et al.'s (2010) enhancements to the methodology. Including a team of researchers with bilingual capabilities will not limit the research to a single language. Furthermore, there will be less likelihood of human error during the scoping review process.

Considering the conclusions of the present research study, further investigation into the field is warranted due to the limited scope of literature. As an additional motivation to conduct research within the field, many of the research results are conflicting in nature, thus, by better understanding the effects that music characteristics have on anxious and stress responses, music treatments can be improved.

Specifically, future research should focus on RR, SCL/SCR, HRV, stress, anxiety and perceived relaxation as these were the least studied among the included studies. Similarly, when considering participant characteristics, an additional focus on male participants would be beneficial, as the majority of studies included in the scoping review investigated psychophysiological responses of females. As with the research conducted by Jacquet et al. (2014), gender was found to be a moderating factor of experienced valence when pitch changes occurred. A suggestion for future research is for gender differences to be investigated in relation to basic music characteristics, such as pitch, tempo, intensity and timbre. Investigation into gender differences will provide additional insight into possible moderating relationships, and further the understanding of music usage during MT, MBT or relaxation techniques to quell anxiety or stress.

It would be beneficial to explore the effects of music in younger individuals (below 18 years), as well as ages above 30 years, as there is limited empirical evidence on these cohorts. As with the recommendations on further investigating differences in gender and music characteristics, the same suggestion applies to age. This investigation could build on the results of Kazymov et al. (2014) which noted that older adolescents' (age 17-18) preference for faster tempos also decreased situational anxiety. Additional exploration into the relationship between age, tempo, music preferences and mental illnesses could be considered. As Kazymov et al. (2014) suggest, it is possible that music preference and felt emotions could be linked, and while Hunter et al. (2010) investigated how current listeners' feelings may impact music perception, further research should be conducted to understand the full extent of the relationship.

South African research should also be an area of exploration, because as of the time of the current research study, there has been no recent investigation into the effects of musical characteristics on psychophysiological responses of anxiety and stress utilising a South African population. An investigation into the South African population will provide local context of the subject matter, which could also be compared to the current available research for preliminary population differences. It may also provide insight into better management, coping, treatment and intervention of anxiety and stress within a South African context and population.

Interestingly, Hernandez-Ruiz et al. (2020) remarks that there is a lack of correspondence between self-reports and psychophysiological correlates of anxiety and stress within their research study. The authors then suggest that both bottom-up and top-down processing of musical characteristics should be investigated together so that a correspondence in results can be explored and addressed. Future research should investigate both top-down and bottom-up processing, much like the research conducted by Juslin et al. (2014). Juslin et al.

(2014) considered changes in emotional arousal to a stimulus (tempo) – which is bottom-up processing- as well as investigating the effects on the brain stem and episodic memory (top-down processing). Research should further explore how these two processes interact with different musical characteristics to find more effective treatment methods for anxiety and stress.

Further considering contradictions in research, future endeavours should thoroughly investigate and consequently select a bpm range that is standard across various studies to ensure comparability. Considering a standard range, the current scoping review has shown that a tempo range of 60-80 bpm is optimal for relaxation, and thus could affect psychophysiological correlates of stress and anxiety.

Relating to a bpm within a range of 60-80 bpm is the concept of tempo entrainment, studied by Főldes et al. (2017). Considering Főldes et al.'s (2017) research, there is an opportunity to further investigate how music can quell anxious responses to getting an MRI. Due to there being no statistical significance between the two music groups in Foldes et al's (2017) study (one group with music synchronised to the MRI pulsation sounds and one with music played at original tempo), additional research would expand understanding on the effects of tempo on anxiety or stress. Főldes et al. (2017) mention that the lack of statistical significance may have been due to a small sample size, thus future research should take this into account and utilise a sample with more than 60 participants.

While tempo has been proven to have a large effect on stress and anxiety (see 4.3.1.1.) -including the psychophysiological correlates of stress and anxiety- other auditory characteristics should be investigated, such as intensity, pitch and timbre. Elicited responses from changes in intensity, pitch and timbre might result in new opportunities to decrease psychophysiological symptoms of stress and anxiety.

Additionally, the interplay between music characteristics could be an interesting avenue of research with the goal to reduce anxiety and stress. As with van der Zwaag et al.'s (2011) research, tempo, percussiveness and mode were utilised simultaneously in the research. Due to this combined approach of music characteristics, definitive effects of tempo cannot be made, however positive effects on psychophysiological arousal can be inferred from the results (faster tempos resulted in higher emotional and physiological arousal, thereby inferring that slow tempos reduce emotional and physiological arousal). The content analysis suggests that combinations of certain auditory characteristics may be a promising treatment for anxiety and stress. Moreover, future scoping reviews could focus on a larger range of auditory characteristics as a starting point.

REFERENCES

Aghamohamadi, D., Eidy, M., Pourfathi, H., Hoseinzadeh, H., Sharabiani, B. A., & Golzari, S. (2010). Comparison of Cardiac Stress Index with rate pressure product in trans - abdominal prostatectomy. *Journal of Cardiovascular and Thoracic Research, 2*(1), 35-28. https://www.researchgate.net/publication/233000515_Comparison_of_Cardiac_Stress_Index_with_Rate_Pressure_Product_in_Trans_-_Abdominal_Prostatectomy

Alagha, J., & Ipradjian, A. (2017). The effects of different types of music on stress levels. *Global Journal of Human-Social Science: Arts & Humanities – Psychology*, *17*(5). https://globaljournals.org/GJHSS_Volume17/1-The-Effects-of-Different.pdf

Allgulander, C. (2010). Morbid anxiety as a risk factor in patients with somatic diseases: A review of recent findings. *European Neurological Journal, 2*(1), 1-9. https://www.proquest.com/openview/a072bcb9d89db719d37d7d97280a0f8c/1?pq-origsite=gscholar&cbl=135343

American Psychiatric Association. (2021). *What Are anxiety disorders?* https://www.psychiatry.org/patients-families/anxiety-disorders/what-are-anxiety-disorders

Arjmand, H., Hohagen, J., Paton, B., & Rickard, N. S. (2017). Emotional responses to music: Shifts in frontal brain asymmetry mark periods of musical change. *Frontiers in Psychology, 8,* 2044. https://doi.org/10.3389/fpsyg.2017.02044

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*, *8*(1), 19-32. https://doi.org/10.1080/1364557032000119616

Barlow, D. H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* (2nd ed.). New York: Guilford.

Beri, D., & Reddy, J. (2019). Physiological correlates of arousal: A meta-analytic review. *Journal of Neurology and Neuroscience,* 10(1), 1-4. 10.36648/2171-6625.10.4.302

Berti, S., Vossel, G., & Gamer, M. (2017). The orienting response in healthy aging: novelty P3 indicates no general decline but reduced efficacy for fast stimulation rates. *Frontiers in Psychology*, *8*(1780), 1-14. 10.3389/fpsyg.2017.01780

Blascovich, J., Vanman, E. J., Mendes, W. B., & Dickerson, S. (2011). *Social*

Psychophysiology for Social and Personality Psychology. The Sage Library of Methods in Social and Personality Psychology. https://dx.doi.org/10.4135/9781446287842

Boer, D. (2009). *Music makes the people come together: Social functions of music listening for young people across cultures*. [Doctorate thesis, University of Wellington]. ResearchGate. https://www.researchgate.net/publication/41211262_Music_Makes_the_People_Come_Together_Social_Functions_of_Music_Listening_for_Young_People_Across_Cultures.

Braithwaite, J. J., Watson, D. G., Jones, R., & Rowe, M. (2015). *A guide for analysing electrodermal activity (EDA) & skin conductance responses (SCRs) for psychological experiments* [Biopac Guide]. https://www.biopac.com/wp-content/uploads/EDA-SCR-Analysis.pdf

Bussiek, p. v., Poli, C. D., & Bevan, G. (2018). A scoping review protocol to map the evidence on interventions to prevent overweight and obesity in children. *BMJ Open, 8,* 1-6. http://dx.doi. org/10.1136/bmjopen-2017- 019311

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. G. (2007). *Handbook of psychophysiology.* New York: Cambridge University Press. https://doi.org/10.1017/9781107415782

Calitz, C. J. (2017). Healing liturgy: The role of music and singing. *Verbum et Ecclesia, 38*(1), 1-19. https://verbumetecclesia.org.za/index.php/ve/article/view/1628/3178

Carpentier, D., & Potter, R. F. (2007). Effects of music on physiological arousal: Explorations into tempo and genre. *Media Psychology, 10*(3), 339-363. https://doi.org/10.1080/15213260701533045

Chalmers, J. A., Quintana, D. S., Abbott, M. J., & Kemp, A. H. (2014). Anxiety disorders are associated with reduced heart rate variability: A meta-analysis. *Frontiers in Psychiatry, 5(*80), 1-11. 10.3389/fpsyt.2014.00080.

Chuen, L., Sears, D., & McAdams, S. (2016). Psychophysiological responses to auditory changes. *Psychophysiology, 53,* 891-904. 10.1111/psyp.12633

Colquhoun, H. L., Levac, D., O'Brien, K. K., Straus, S., Tricco, A. C., Perrier, L., Kastner, M., & Moher, D. (2014). Scoping reviews: Time for clarity in definition, methods, and reporting. *Journal of Clinical Epidemiology, 67,* 1291-1294. http://dx.doi.org/10.1016/j.jclinepi.2014.03.013

Cook, M. A. (2012). *Music theory* [Manual Shepherd University]. https://www.ebooksdirectory.com/details.php?ebook=12259

Coutinho, E. (2011). Musical emotions: Predicting second-by-second subjective feelings of emotion from low-level psychoacoustic features and physiological measurements. *Emotion, 11(*4), 921-937. 10.1037/a0024700

Cretikos, M. a., Bellomo, R., Hillman, K., Chen, J., Finfer, S., & Flabouris, A. (2008). Respiratory rate: The neglected vital sign. *The Medical Journal of Australia, 11,* 657-659. 10.5694/j.1326-5377.2008.tb01825.x

Croft, R. J., Gonsalvez, C. J., Gander, J., Lechem, L., Barry, R. J. (2004). Differential relations between heart rate and skin conductance, and public speaking anxiety. *J. Behav. Therapy Exp. Psychiatry*, *35*, 259–271. 10.1016/j.jbtep.2004.04.012

Crusius, C. (2018, October). *Research-based music composition for anxiety* [Honor's thesis Western Michigan University]. ScholarWorks at MWU. https://scholarworks.wmich.edu/cgi/viewcontent.cgi?article=4085&context=honors_theses

Curtin, M. (2017, May). *Neuroscience says listening to this song reduces anxiety by up to 65 percent.* Inc. https://www.inc.com/melanie-curtin/neuroscience-says-listening-to-this-one-song-reduces-anxiety-by-up-to-65-percent.html

Cypress, B. S. (2017). Rigor or reliability and validity in qualitative research: Perspectives, strategies, reconceptualization, and recommendations. *Dimensions of Critocal Care Nursing*, *36*(4), 253-263. 10.1097/01.DCC.0000520273.44035.13

D'Avanzato, C., Joormann, J., Siemer, M., & Gotlib, I. H. (2013). Emotion regulation in depression and anxiety: Examining diagnostic specificity and stability of strategy use. *Cognitive Therapy Research, 37,* 968-980. 10.1007/s10608-013-9537-0

Davis, K. R., & Fischer, S. (2012). The influence of trait anger, trait anxiety and negative urgency on disordered eating. *Personality and Individual Differences*, *54*(2013), 307-310. http://dx.doi.org/10.1016/j.paid.2012.08.036

Devi, C. B. P., Reddy, M. A., Zahan, O., & Sharma, J. V. C. (2019). The effect of stress on human life. *Adalya Journal, 8*(9), 792-811. https://www.researchgate.net/publication/337445248_THE_EFFECT_OF_STRESS_ON_HUMAN_LIFE

Deckert, M., Schmoeger, M., Auff, E., & Willinger, U. (2019). Subjective emotional arousal: An explorative study on the role of gender, age, intensity, emotion regulation difficulties, depression and anxiety symptoms, and meta-emotion. *Psychological Research, 7,* 1857-1876. 10.1007/s00426-019-01197-z

Dieleman, G. C., van der Ende, J., Verhulst, F. C., & Huizink, A. C. (2010). Perceived and

physiological arousal during a stress task: Can they differentiate between anxiety and depression?. *Psychoneuroendocrinology, 35*(8), 1223-1234. 10.1016/j.psyneuen.2010.02.012.

Du, J., Huang, J., An, Y., & Xu, W. (2018). The relationship between stress and negative emotion: The mediating role of rumination. *Clinical Research Trials, 4*(1), 1-5. 10.15761/CRT.1000208

Ebnesshahidi, A. (2017). *Autonomic nervous system* [PowerPoint slide]. https://www.academia.edu/32138687/Autonomic_Nervous_System

Eerola, T., & Vuoskoski, J. K. (2012). Can sad music really make you sad? Indirect measures of affective states induced by music and autobiographical memories. *Psychology of Aesthetics, Creativity, and the Arts, 6*(3), 204–213. https://doi.org/10.1037/a0026937

Frijda, N. H., & Mesquita, B. (1994). The social roles and functions of emotions. In S. Kitayama & H. R. Markus (Eds.), Emotion and culture: Empirical studies of mutual influence (pp. 51–87). American Psychological Association. https://doi.org/10.1037/10152-002Davidson 2006

Gravetter, F. J., & Forzano, L. B. (2012). *Research methods for the behavioural sciences.* Stamford, United States of America: Cengage Learning.

Gingrich, J. A. (2002). Mutational analysis of the serotonergic system: Recent findings using knockout mice. *Curr Drug Targets, 1*(5), 449–465. 10.2174/1568007023339003.

Habibzadeh, S. E. (2015). The effect of music on mental and physical performance. *Physical Activity Review, 3*, 32-36. 10.16926/par.2015.01.04

Hainaut, J. P., & Bolmont, B. (2005). Effects of mood states and anxiety as induced by the video-recorded Stroop color-word interference test in simple response time tasks on reaction time and movement time. *Percept Mot Skills, 101*(3), 721-729. 10.2466/pms.101.3.721-729.

Hanson-Abromeit, D. (2015). A conceptual methodology to define the therapeutic function of music. *Music Ther. Perspect. 33*, 25–38. doi: 10.1093/mtp/miu061

Hearing Health Foundation. (n.d.). *Decibel level.* Hearing Health Foundation. https://hearinghealthfoundation.org/decibel-levels

Heiderscheit, A., & Madson, A. (2015). Use of the Iso Principle as a central method in mood management: A musical psychotherapy clinical case study. *Music Therapy Perspective, 33*(1), 45-52. 10.1093/mtp/miu042

Henning, E. (2014). *Effects of gender & lifestyle on Cardio Stress Index & heart rate*

variability (Master's thesis). https://repository.up.ac.za/bitstream/handle/2263/43207/Nortje_Effect_2014.pdf?

Hohmann, L., Bradt, J., Stegemann, T., & Koelsch, S. (2017). Effects of music therapy and music-based interventions in the treatment of substance use disorders: A systematic review. *PLoS ONE, 12*(11), 1-36. https://doi.org/10.1371/journal.pone.0187363

Hunter, P. G., Schellenberg, E. G., & Schimmack, U. (2010). Feelings and perceptions of happiness and sadness induced by music: Similarities, differences, and mixed emotions. *Psychology of Aesthetics, Creativity, and the Arts, 4*(1), 47–56. https://doi.org/10.1037/a0016873

Huron, D. (2006). *Sweet anticipation: Music and the psychology of expectation.* England: The MIT Press. https://doi.org/10.7551/mitpress/6575.001.0001

Huron, D. (2013). A psychological approach to musical form: The habituation–fluency theory of repetition. *Current Musicology, 96,* 7-35. https://doi.org/10.7916/cm.v0i96.5312

Husain, G., Thompson, W. F., & Schellenberg, E. G. (2002). Effects of musical tempo and mode on arousal, mood and spatial abilities. *Music Perception, 20*(2), 151-171. 10.1525/mp.2002.20.2.151

Iakovides, S., Iliadou, V., Bizeli, V., Kaprinis, S. G., Fountoulakis, K. N., & Kaprinis, G. S. (2004). Psychophysiology and psychoacoustics of music: Perception of complex sound in normal subjects and psychiatric patients. *Annals of General Hospital Psychiatry, 3*(6), 1-4. 10.1186/1475-2832-3-6 ·

Imran, S., Moosaba, M., S., & Ancheril, A. (2017). Effects of music therapy on anxiety, blood pressure and respiratory rate in patients undergoing chemotherapy. Nursing & Care Open Access Journal, *2*(6), 156-158. 10.15406/ncoaj.2017.02.00053

Jerath, R., Crawford, M. W., Barnes, V. A., Harden, K. (2015). Self-regulation of breathing as a primary treatment for anxiety. *Appl Psychophysiol Biofeedback, 40*(2):107-15. 10.1007/s10484-015-9279-8.

Jiang, J., Rickson, D., & Jiang, C. (2016). The mechanism of music for reducing psychological stress: Music preference as a mediator. The Arts in Psychotherapy, 48, 62-58. http://dx.doi.org/10.1016/j.aip.2016.02.002

Joiner, T. E., & Schmidt, N. B. (1995). Dimensions of perfectionism, life stress, and depressed and anxious symptoms: prospective support for diathesis-stress but not specific vulnerability among male undergraduates. *Journal of Social and Clinical Psychology, 14(*2), 165-183. https://doi.org/10.1521/jscp.1995.14.2.165

Juslin, P. N. (2001). Communicating emotion in music performance: A review and a theoretical framework. In P. N. Juslin & J. A. Sloboda (Eds.), *Music and emotion: Theory and research* (pp. 309–337). Oxford University Press.

Juslin, P. N. (2013). What does music express? Basic emotions and beyond. *Frontiers in Psychology, 4*(596), 1-14. 10.3389/fpsyg.2013.00596

Juslin, P. N., & Västfjäll, D. (2008). Emotional responses to music: The need to consider underlying mechanisms.. *Behavioral and Brain Sciences, 31*(6), 751. https://doi.org/10.1017/S0140525X08006079

Kellaris, J. J., & Kent, R. (1991). Exploring tempo and modality effects, on consumer responses to music. *Advances in Consumer Research, 18,* 243-248. https://www.acrwebsite.org/volumes/7168/volumes/v18/NA-18

Kelley, E., Andrick, G., Benzenbower, F., & Devia, M. (2014). Physiological arousal response to differing musical genres. *Modern Psychological Studies, 20(*1), 25-36. https://scholar.utc.edu/mps/vol20/iss1/4/

Kendler, K. S., Hettema, J. M., Butera, F., Gardner, C. O., & Prescott, C. A. (2003). Life event dimensions of loss, humiliation, entrapment, and danger in the prediction of onsets of major depression and generalized anxiety. *Arch Gen Pschiatry, 6*-(8), 789-769. 10.1001/archpsyc.60.8.789

Killin, A. (2017). The origins of music: Evidence, theory, and prospects. *Music & Science, 1,* 1-23. 10.1177/2059204317751971

Kim, H., Cheon, E., Bai, D., Lee, Y. H., & Koo, B. (2017). Stress and heart rate variability: A meta-analysis and review of the literature. *Psychiatry Investigations, 15(*3), 235-245. 10.30773/pi.2017.08.17.

Kuo, J. R., Goldin, P.R., Werner, K., Heimberg, R. G., & Gross, J. J., 2011. Childhood trauma and current psychological functioning in adults with social anxiety disorder. *Journal of Anxiety Disorders, 25*(4), 467–473. 10.1016/j.janxdis.2010.11.011.

Landreth, J. E., & Landreth, H. F. (1974). Effects of music on physiological response. *Journal of Research in Music Education, 22*(1), 4-12. http://dx.doi.org/10.2307/3344613

Lazarus, R. S. (1993). From psychological stress to the emotions: A history of changing outlooks. *Annual Review of Psychology, 44,* 1-21. http://dx.doi.org/10.1146/annurev.ps.44.020193.000245

Leedy, P. D., & Ormrod, J. E. (2013). *Practical research: Planning and design.* Boston: Pearson.

Lehrer, P. M., Woolfolk, R. L., & Sime, W. E. (Eds.) (2007). *Principles and practices of stress management* (3rd ed.). Guilford Press.

Levac, D., Colquhoun, H. & O'Brien, K. K. (2010). Scoping studies: advancing the methodology. *Implementation Sci, 5*, 69. https://doi.org/10.1186/1748-5908-5-69

Lilley, J. L., Oberle, C. D., & Thompson, J.G. (2014). Effects of music and grade consequences on test anxiety and performance. *Psychomusicology: Music, Mind, and Brain*, *24*(2), 184-190. 10.1037/pmu0000038

Lui, Y., Guangyuan, L., Dongtao, W., Qiang, Li., Guangjie, Y., Shifu, W., Gapyuan, W., & Xingcong, Z. (2018). Effects of musical tempo on musicians' and non-musicians' emotional experience when listening to music. *Frontiers in Psychology*, *9*, 2118. 10.3389/fpsyg.2018.02118

Lundqvist, L., Carlsson, F., Hilmersson, P., & Juslin, P. N. (2009). Emotional responses to music: experience, expression, and physiology. *Psychology of Music, 37*(1), 61-90. 10.1093/oxfordhb/9780199298457.013.0012

Lutscher, D. (2016). *The relationship between skin conductance and self-reported stress* [Bachelors thesis, University of Twente]. Semantic Scholar.

Magnusson, D. (1980). Trait-state anxiety: A note on conceptual and empirical relationships. *Person & Individual Differences, 1*, 215-217. https://doi.org/10.1016/0191-8869(80)90053-7

Maina, G., Mauri, M., & Rossi, A. (2016). Anxiety and depression. *Journal of Psychopathology*, *22*, 236-250. http://www.jpsychopathol.it/wp-content/uploads/2017/02/04_Mauri-Maina-Rossi-1.pdf

Masaoka, Y., & Homma, I. (1997). Anxiety and respiratory patterns: their relationship during mental stress and physical load. *International Journal of Psychophysiology*, *27*(2).152-159. https://doi.org/10.1016/S0167-8760(97)00052-4

Mauss, I. B., Wilhelm, F. H., & Gross, J. J. (2003). Autonomic recovery and habituation in social anxiety. *Psychophysiology*, *40*(4), 648–653. https://doi.org/10.1111/1469-8986.00066

Mays, N., Roberts, E. and Popay, J. (2001) Synthesising research evidence. In N. Fulop, P. Allen, A. Clarke and N. Black (Eds.) *Studying the organisation and delivery of health services: research methods* (pp 188-220). London: Routledge.

McAdams, S., & Giordano, B. L. (2008). The perception of musical timbre. In S. Hallam, I. Cross & M. H. Thaut. (Eds.), *The Oxford handbook of music* psychology (2nd Ed., pp. 72-80). Oxford University Press. 10.1093/oxfordhb/9780198722946.013.12

McCraty, R., & Tomasino, D. (2006). Emotional stress, positive emotions and psychophysiological coherence. In B. B. Arnetz & R. Ekman (Eds.), *Stress in Health and Disease*, (pp. 342-365). Weinheim.

McEwen, (2014). Physiology and neurobiology of stress and adaptation: central role of the brain. *Physiological Review*, 87, 873-904. 10.1152/physrev.00041.2006.

McDermott, J., & Hauser, M. (2005). The origins of music: innateness, uniqueness, and evolution. *Music Perception, 23*(1), 29-59. https://doi.org/10.1525/mp.2005.23.1.29

McLaughlin, K. A., & Hatzenbuehler, M. L. (2009). Stressful life events, anxiety sensitivity, and internalizing symptoms in adolescents. *Journal of Abnormal Psychology, 118*(3), 659-669. 10.1037/a0016499.

Mental Health Foundation. (2014). *Living with anxiety: Understanding the role and impact of anxiety in our lives.* Mental Health Foundation. https://www.mentalhealth.org.uk/sites/default/files/living-with-anxiety-report.pdf

Miendlarzewska, E. A., & Trost, W. J. (2014). How musical training affects cognitive development: rhythm, reward and other modulating variables. *Frontiers in neuroscience, 7*, 279. https://doi.org/10.3389/fnins.2013.00279

Mills, D., Karagiannis, C., & Zulch, H. (2014). Stress-its effects on health and behavior: a guide for practitioners. *Vet Clin North Am Small Anim Pract, 44*(3), 525-41. 10.1016/j.cvsm.2014.01.005.

Mindlab International. (n.d). Neuroscientists say this is the most relaxing song in the world. Good. https://www.good.is/Health/relaxing-song-ever-recorded-stress

Mochcovich, M. D., Deslandes, A. C., Freire, R. C., Garcia, R. F., & Nardi, A. E. (2016). The effects of regular physical activity on anxiety symptoms in healthy older adults: a systematic review. *Revista Brasileira de Psiquiatria*, (38), 255-261. 10.1590/1516-4446-2015-1893

Modeme, E., & Sunday-Kanu, R. (2014). Music Performance as a therapy for managing stress amongst the academics in nigerian federal universities. *AFRREV IJAH: An International Journal of Arts and Humanities, 3*, 128-145. 10.4314/IJAH.V3I3.10

McKinney, M., & Moelants, D. (2004). Deviations from the resonance theory of tempo induction. In R. Parncutt, A. Kessler, & F. Zimmer (Eds.), *Abstracts of the Conference on Interdisciplinary Musicology (Full text included on CD-rom)* (pp. 124–125). Department of Musicology, University of Graz.

Mori, K., & Iwanaga, M. (2017). Two types of peak emotional responses to music: The

psychophysiology of chills and tears. *Scientific Reports, 7*(46063), 1-13. 10.1038/srep46063.

Mordka, C. (2016). What are emotions? Structure and function of emotions. *Studia Humana, 5*(3), 29-44. 10.1515/sh-2016-0013

Morgenstern, M., & Auhagen, W. (2006). Different effects of auditory stimuli on human autonomic cardiovascular rhythms. Proceeding of the 9th International Conference on Music Perception and Cognition (pp. 1494-1498). Wittenberg, Germany.

Moss, D. (2002). Psychological perspectives: anxiety disorders. In B. Horwitz (Ed.), *Communication apprehension: origins and management,* (1st ed.) (pp. 1-49). Canada: Thompson Learning.

Mottaghi, R., Kamkar, A., & Mardpoor, A. (2015). The effectiveness of targeted music therapy intervention and cognitive-behavioural therapy on sleep quality and symptoms of insomnia disorder in seniors. *The International Journal of Indian Psychology, 2*(4), 114-127. http://oaji.net/articles/2015/1170-1442392713.pdf

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., Aromataris, E. (2018). Guidance for authors when choosing between a systematic or scoping review approach. *Medical Research Methodology, 18*(143), 1-7. https://doi.org/10.1186/s12874-018-0611-x

Murrock, C. J. (2016). Concept analysis: Music therapy. *Research and Theory for Nursing Practice: An International Journal, 30*(1), 44-49. https://doi.org/10.1891/1541-6577.30.1.44

Nabi, H., Hall, M., Koskenvuo, M., Singh-Manoux, A., Oksanen, T., Suominen, S., Kivimaki, M., & Vahtera, J. (2010). Psychological and somatic symptoms of anxiety and risk of coronary heart disease: the health and social support prospective cohort study. *Biological Psychiatry, 67*, 378-385. http://dx.doi.org/10.1016/j.biopsych.2009.07.040

Nechita, D., Nechita, F., & Motorga, R. (2018). A review of the influence the anxiety exerts on human life. *Romanian Journal of Morphology & Embryology, 59*(4), 1045-1051.

Nolen-Hoeksema, S. (2017). *Abnormal psychology.* New York, NY: McGraw-Hill Education.

Nutt, D., de Miguel, B. G., & Davies, S. J. C. (2008). Phenomenology of anxiety disorders. In R. J. Blanchard, D. C. Blanchard, G. Griebel, & D. Nutt (Eds.), H*andbook of Anxiety and Fear*, (Vol. 17 pp. 365-393). Oxford: Elsevier.

O'Hagan, E. (2016). *The relationship between listening to music and feelings of anxiety and*

happiness in young adults. [Bachelor of Arts, Dublin Business School of Arts]. Esource. https://esource.dbs.ie/handle/10788/3034

Osmanoglu, E. D., & Yilmaz, H. (2019). The effect of classical music on anxiety and well-being of university students. *International Education Studies, 12(*11), 18-25. 10.5539/ies.v12n11p18

Panteleeva, Y., Ceschi, D. G., Courvoisier, D. S., & Grandjean, D. (2017). Music for anxiety? Meta-analysis of anxiety reduction in non-clinical samples. *Psychology of Music*, 1-15. 10.1177/0305735617712424

Park, C. L., & Iacocca, M. O. (2013). A stress and coping perspective on health behaviors: Theoretical and methodological considerations. *Anxiety, Stress & Coping, 27*(2), 123-137. http://dx.doi.org/10.1080/10615806.2013.860969

Pascoe, M. C., Hetrick, S. E., & Parker, A. G. (2020). The impact of stress on students in secondary school and higher education. *International Journal of Adolescence and Youth, 25*(1), 104-112. https://doi.org/10.1080/02673843.2019.1596823

Pavlicevic, M. (1999). Music therapy improvisation groups with adults: towards de-stressing in South Africa. *South African Journal of Psychology, 29*(2), 94-99. https://doi.org/10.1177%2F008124639902900206

Persad, L., Govender, C., Soma, P., Toit, P.J., Kruger, P.E., Grant, C.C., & Wood, P.S. (2012). Postural variations in Cardio Stress Index scores. *African Journal for Physical, Health Education, Recreation and Dance, 18*, 90-98. 10.4314/AJPHERD.V18I1

Petersen, J. (2001). Understanding scoping reviews: Definition, purpose, and process. *Journal of the American Association of Nurse Practitioners, 29,* 12-16. 10.1002/2327-6924.12380

Pilhofer, M., & Day, H. (2007). *Music theory for dummies.* Indiana: Wiley Publishing Inc.

Pittig, A., Arch, J. J., Lam, C. W. R., & Craske, M. G. (2012). Heart rate and heart rate variability in panic, social anxiety, obsessive-compulsive and generalized anxiety disorders at baseline and in response to relaxation and hyperventilation. *International Journal of Psychophysiology*, *87*, 19-27. https://doi.org/10.1016/j.ijpsycho.2012.10.012

Pop, M. G., Crivvi, C., & Opincariu, I. (2018). *Anatomy and function of the hypothalamus.* Web of Science. http://dx.doi.org/10.5772/intechopen.80728

Pothoulaki, M., MacDonald, R., A., R., Flowers,P., Stamataki, E., Filiopoulos, D.,

Stamatiadis, D., & Stathakis, P. (2008). An investigation of the effects of music on anxiety and pain perception in patients undergoing haemodialysis treatment. *Journal of Health Psychology*, 13(7), 912-920. 10.1177/1359105308095065

Quintana, D. S., & Heathers, J. A. (2014). Considerations in the assessment of heart rate variability in biobehavioral research. *Front Psychol, 22(5),* 805. 10.3389/fpsyg.2014.00805.

Ray, A., Gulati, K., & Rai, N. (2017). Stress, anxiety, and immunomodulation: A pharmacological analysis. *Elsevier, 103,* 1-25. 10.1016/bs.vh.2016.09.007

Reinelt, E., Stopsack, M., Aldinger, M., John, U., Grable, H. J., & Barnow, S. (2013). Testing the diathesis-stress model: 5-httlpr, childhood emotional maltreatment, and vulnerability to social anxiety disorder. *American Journal of Medical Genetics, (Part B)*162, 253-261. 10.1002/ajmg.b.32142

Rita, M. D., & Adaobi, S. R. (2014). Music performance as a therapy for managing stress amongst the academics in Nigerian federal universities. *An International Journal of Arts and Humanities, 3*(3), 128-145. http://dx.doi.org/10.4314/ijah.v3i3.10

Ronan, D., Reiss, J. D., & Gunes, H. (2018). An empiral approach to the relationship between emotion and music production quality. *Journal of Latex Class Files,* 1-12. https://www.researchgate.net/publication/324104687_An_empirical_approach_to_the_relationship_between_emotion_and_music_production_quality

Rosebrock, L. E., Hoxha, D., Norris, C., Cacioppo, J. T., & Gollan, J. K. (2017). Skin conductance and subjective arousal in anxiety, depression, and comorbidity: Implications for affective reactivity. *Journal of Psychophysiology*, *31*(4), 145–157. https://doi.org/10.1027/0269-8803/a000176

Sacha, J. (2014). Interaction between heart rate and heart rate variability. *Annual Noninvasive Electrocardiology*, *19*(3), 207-216. 10.1111/anec.12148

Schmidt, C. K., Khalid, S., Loukas, M., & Tubbs, R. S. (2018) Neuroanatomy of anxiety: A brief review. *Cureus, 10*(1), 2055. 10.7759/cureus.2055

Schmidt-Jones, C. (2003). *Understanding basic music theory.* Houston: Rice University. http://cnx.org/content/col10363/1.3/

Schneiderman, N., Ironson, G., & Siegel, S. D. (2005). Stress and health: Psychological, behavioural, and biological determinants. *Annual Review of Clinical Psychology, 1,* 607-628. 10.1146/annurev.clinpsy.1.102803.144141

Shahsavarani, A. M., Abadi, E. A. M., & Kalkhoran, M. H. (2015). Facts and theories

through literature review. *International Journal of Medical Reviews*, *2*(2), 230-241. http://www.ijmedrev.com/article_68654_37adc02e9432adfa017b8d6095cb6760.pdf

Shannahoff-Khalsa, D. (2008). Psychophysiological states: The ultradian dynamics of mind–body interactions. *International Review of Neurobiology*, *80*, 1-220. 10.1016/S0074-7742(07)80001-8

Sloboda, J. A., (1999). Everyday uses of music listening: A preliminary study. In S. W. Yi (Ed.), *Music, mind & science* [preliminary paper]. 10.1093/acprof:oso/9780198530121.003.0018

Smith, D. B. (1976). *Differences between anxiety patients and normal in phasic skin conductance reactions to heteromodal stimulation* [Masters dissertation]. https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=3111&context=theses

Smith, P. J., & Blumenthal. J. A. (2011). Psychiatric and behavioral aspects of cardiovascular disease: epidemiology, mechanisms, and treatment. *Revista Española de Cardiología*, *64*(10), 924-933. 10.1016/j.rec.2011.06.003

Song, Y., Dixon, S., Pearce, M. T., & Halpern, A. R. (2016). Perceived and Induced Emotion Responses to Popular Music: Categorical and Dimensional Models. *Music Perception: An Interdisciplinary Journal*, *33*(4), 472–492. https://www.jstor.org/stable/26417432

Spielberger, C. D., Gorsuch, R. L., & Lushene, R. E. (1970). *Manual for the state-trait anxiety inventory*. Palo Alto, California: Consulting Psychologist Press.

Spielberger, C. D., & Reheiser, E. C. (2009). Assessment of emotions: Anxiety, anger, depression, and curiosity. *Applied Psychology: Health and Well-Being*, *1*(3), 271-302. 10.1111/j.1758-0854.2009.01017.x

Spielberger C. D., Reheiser E. C. (2003). Measuring anxiety, anger, depression, and curiosity as emotional states and personality traits with the STAI, STAXI, and STPI. In M. Hersen, M. J. Hilsenroth, & D. L., Segal (Eds.), *Comprehensive handbook of psychological assessment vol. 2: personality assessment.* John Wiley & Sons, Hoboken, NJ.

Stanton, J. M., Balzer, W. K., Smith, P. C., Parra, L. F., & Ironson, G. (2001). A general measure of work stress: The Stress in General scale. *Educational and Psychological Measurement, 61*(5), 866–888. https://doi.org/10.1177/00131640121971455

Steelman, V. M. (1991). Relaxing to the beat: Music therapy in perioperative nursing. *Todays OR Nurse, 13*(7), 18-22. https://pubmed.ncbi.nlm.nih.gov/1853431/

Stevenson, S., Bobrowski, P., Knipschild, A., & Robinson, J. (2016). Physiological and

psychological effects of music. *Auburn University Journal of Undergraduate Scholarship,* 32-33. http://our.auburn.edu/wp-content/uploads/2020/12/2016-AUJUS-issue-V3-final.pdf

Svorc, P. (2018). *Autonomic Nervous System.* Intechopen. http://dx.doi.org/10.5772/intechopen.81026

Tanguy, G., Sagui, E., Fabien, Z., Martin-Krumm, C., Canini, F., & Trousselard, M. (2018). Anxiety and psycho-physiological stress response to competitive sport exercise. *Frontiers in Psychology, 9,* 1469. 10.3389/fpsyg.2018.01469

Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K., Colquhoun, H., Kastner, M., Levac, D., Ng, C., Sharpe, J. P., Wilson, K., Kenny, M., Warren, R., Wilson, C., Stelfox, H. T., & Straus, S. E. (2016). A scoping review on the conduct and reporting of scoping reviews. *BMC Medical Research Methodology, 16*(15), 1-10. 10.1186/s12874-016-0116-4

Vahtera, J. (2010). Psychological and somatic symptoms of anxiety and risk of coronary heart disease: the health and social support prospective cohort study. *Biological Psychiatry, 67*(4), 378-385. 10.1016/j.biopsych.2009.07.040

Van Ameringen, M., & Pollack, M. (2012). *Generalized anxiety disorders.* England: Oxford University Press.

Vitasari, P., Wahab, M. N. A., Herawan, T., Sinnadurai, S. K., Othman, A., & Awang, M. G. (2011). Assessing of psychological arousal and cognitive anxiety towards academic performance: The application of the catastrophe model. Procedia- Social and Behavioural Sciences, 30, 615-619. https://doi.org/10.1016/j.sbspro.2011.10.119

Volkinburg, H. V., & Balsam, P. (2014). Effects of emotional valence and arousal on time perception. *Timing and Time Perception, 2*(3), 360-378. 10.1163/22134468-00002034

Wallin, N. L., Merker, B., & Brown, S. (2000). *The origins of music.* A Bradford Book.

Wang, M., & Saudino, K. J. (2011). Emotion regulation and stress. *Journal of Adult Development, 18,* 95-103. 10.1007/s10804-010-9114-7

Weiten, W. (2014). *Psychology themes and variations.* Cengage Learning.

White, M. D., & Marsh, E. E. (2006). Content analysis: A flexible methodology. *Library Trends, 55*(1), 22-45. 10.1353/lib.2006.0053

Zarate, R. (2012). *The sounds of anxiety: A quantitative study of music therapy and anxiety*

[Doctorate Thesis]. https://digitalcommons.lesley.edu/cgi/viewcontent.cgi?article=1060&context=expressive_dissertations

Zarbova, B., & Karabeliova, S. (2016). Stress and well-being. Conference: 12th International Conference Days of Applied Psychology 2016 "Contemporary Psychology and Practice" At: University of Nish, Serbia. https://www.researchgate.net/publication/322635070_Stress_and_well-being

APPENDIX A

References of research studies included in the present scoping review

Berger, D. S. (2011). Pilot Study investigating the efficacy of tempo-specific rhythm interventions in music-based treatment addressing hyper-arousal, anxiety, system pacing, and redirection of fight-or-flight fear behaviors in children with Autism Spectrum Disorder (ASD). *Journal of Biomusical Engineering, 2,* 1-15. 10.4303/jbe/M110902

Brownlow, B. (2017). The effect of music tempo on the psychophysiological measures of stress. *Continuum Undergraduate Research Journal,* 8-16. https://www.semanticscholar.org/paper/The-Effect-of-Music-Tempo-on-the-Measures-of-Stress-Brownlow/b467c3ff2a3aefb6a43eceadbb6ea299b3d47bc4

Chuen, L., Sears, D., & McAdams, S. (2016). Psychophysiological responses to auditory changes. *Psychophysiology, 53,* 891-904. 10.1111/psyp.12633

De Witte, M., Spruit, A., van Hooren, S., Moonen, X., & Stams, G. (2019). Effects of music interventions on stress-related outcomes: a systematic review and two meta-analyses. *Health Psychology Review,* 10.1080/17437199.2019.1627897

Földes, Z., Ala-Ruona, E., & Burger, B. (2017). Anxiety reduction with music and tempo synchronization on magnetic resonance imaging patients. *Psychomusicology: Music, Mind, and Brain, 27*(4), 343-349. http://dx.doi.org/10.1037/pmu0000199

Goldschmidt, D. (2020). *Investigating the Iso Principle: The effect of musical tempo manipulation on arousal shift* [Master's thesis]. ProQuest.

Groux, S. L., & Verschure, P. (2012). *Subjective emotional responses to musical structure, expression and timbre features: A synthetic approach* [9th International Symposium on Computer Music Modelling and Retrieval]. Queen Mary University of London. https://ccrma.stanford.edu/~slegroux/publications/pubs/CMMR2012.pdf

Hernandez-Ruiz, E., James, B., Noll, J., & Chrysikou, E. G. (2020). What makes music relaxing? An investigation into musical elements. *Psychology of Music, 48*(3), 327-343. doi:10.1177/0305735618798027

Hunter, P. G., Schellenberg, E. G., & Schimmack, U. (2010). Feelings and perceptions of happiness and sadness induced by music: Similarities, differences, and mixed emotions. *Psychology of Aesthetics, Creativity, and the Arts, 4*(1), 47–56. https://doi.org/10.1037/a0016873

Jacquet, L., Danhuser, B., & Patrick, G. (2014). Music and felt emotions: How systematic pitch level variations affect the experience of pleasantness and arousal. *Psychology of Music, 42*(1), 51-70. 10.1177/0305735612456583

Juslin, P., Harmat, L., & Eerola, T. (2014). What makes music emotionally significant? Exploring the underlying mechanisms. *Psychology of Music, 42*(2). 10.1177/0305735613484548

Kazymov, A. G., Mamedov, A. M., Alieva, D. M., & Chobanova, O. M. (2014). Autonomic and psychophysiological correlates of the effects of music therapy in neurotic disorders. *Neuroscience and Behavioral Physiology, 44,* 60-63. https://pubmed.ncbi.nlm.nih.gov/23250598/

Kim, S., Gäbel, C., Aguilar-Raab, C., Hillecke, T. K., & Warth, M. (2018). Affective and autonomic response to dynamic rhythmic entrainment: Mechanisms of a specific music therapy factor. *The Arts in Psychotherapy, 60,* 48-54. https://doi.org/10.1016/j.aip.2018.06.002.

Krabs, R. U., Enk, R., Teich, N., & Koelsch, S. (2015). Autonomic effects of music in health and Crohn's disease: The impact of isochronicity, emotional valence, and tempo. *PLoS ONE 10*(5). https://doi.org/10.1371/journal.pone.0126224

Ooishi, Y., Mukai, H., Watanabe, K., Kawato, S. & Kashino, M. (2017). Increase in salivary oxytocin and decrease in salivary cortisol after listening to relaxing slow-tempo and exciting fast-tempo music. *Plos One, 12*(12). https://doi.org/10.1371/journal.pone.0189075

Shoda, H., Adachi, M., & Umeda, T. (2016). How live performance moves the human heart. *PLoS ONE, 11*(4). https://doi.org/10.1371/journal.pone.0154322

Stith, C. C. (2015). *The effects of musical tempo and dynamic range on heart rate variability in healthy adults: a counterbalanced, within-subjects study* [Master's thesis]. Libres.

Tamaliunaite, A. (2017). *Affective and cognitive consequences of temporal and textual aspects of background music* [Master's thesis]. University of Oslo.

Tan, X., Yowler, C. J., Super, D. M., & Fratianne, R. B. (2012) The interplay of preference, familiarity and psychophysical properties in defining relaxation music. *J Music Ther. Summer*,*49*(2), 150-79. 10.1093/jmt/49.2.150.

Van der Zwaag, M. D., Westerink, J. H. D. M., & Broek, E. L. (2011). Emotional and psychophysiological responses to tempo, mode, and percussiveness. Musicae Scientiae, 15(2), 250-269. 10.1177/1029864911403364

Wang, W. (2014). A study of the type and characteristics of relaxing music for college students. *Journal of the Acoustical Society of America, 135*, 2185-2185. 10.1121/1.4877117

APPENDIX B
Ethical Clearance

7 February 2020

Dear Miss S Maharaj

Project Title:	Psychophysiological responses of anxiety or stress in students to basic auditory changes of musical characteristics.
Researcher:	Miss S Maharaj
Supervisor:	Dr N Coetzee
Department:	Psychology
Reference number:	15033695 (HUM041/1019)
Degree:	Masters

I have pleasure in informing you that the above application was **approved** by the Research Ethics Committee on 7 February 2020. Data collection may therefore commence.

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the proposal. Should the actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely

Prof Maxi Schoeman
Deputy Dean: Postgraduate and Research Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail: PGHumanities@up.ac.za

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Fakulteit Geesteswetenskappe
Lefapha la Bomotho

Humanities 100.

16 February 2021

Dear Miss S Maharaj

Project Title:	Psychophysiological responses of anxiety or stress to auditory changes in musical characteristics.
Researcher:	Miss S Maharaj
Supervisor(s):	Dr N Coetzee
Department:	Psychology
Reference number:	15033695 (HUM041/1019) (Amendment)
Degree:	Masters

Thank you for the application to amend the existing protocol that was previously approved by the Committee.

The revised / additional documents were reviewed and **approved** on 16 February 2021 along these guidelines, further data collection may therefore commence (where necessary).

Please note that this approval is based on the assumption that the research will be carried out along the lines laid out in the amended proposal. Should your actual research depart significantly from the proposed research, it will be necessary to apply for a new research approval and ethical clearance.

We wish you success with the project.

Sincerely,

Prof Innocent Pikirayi
Deputy Dean: Postgraduate Studies and Research Ethics
Faculty of Humanities
UNIVERSITY OF PRETORIA
e-mail:PGHumanities@up.ac.za

APPENDIX C
Data charting document

Number	Search strategy	Database	Title	Authors	Date Published	Methodology	Population	Sample size	Link
1	Preliminary search		Psychophysiological responses to auditory change	LORRAINE CHUEN,aDAVID SEARS,bAND STEPHEN MCADAMS	2016	Experimental	23 years old mean	40	https://onlinelibrary-wiley-com.uplib.idm.oclc.org/doi/epdf/10.1111/psyp.12633
2	psychophysiology AND music charateristics AND stress	Ebsco host APA PsycInfo	Autonomic and Psychophysiological Correlates of the Effects of Music Therapy in Neurotic Disorders	A. G. Kazymov,1 A. M. Mamedov,1 D. M. Alieva,1 and O. M. Chobanova2	2014	Experimental	Healthy adolescents and adolescents with neurotic disorders, aged 15-18	48 for each group (96 total)	https://link-springer-com.uplib.idm.oclc.org/content/pdf/10.1007/s11055-013-9873-2.pdf

3	psychophysiology AND music AND stress	Ebsco host APA PsycInfo	Affective and autonomic response to dynamic rhythmic entrainment: Mechanisms of a specific music therapy factor	SungeunKim aChristineGäbelbCorinaAguilar-RaabbThomas K.Hilleckea MarcoWarth	2018	Experimental (Pilot)	healthy university students meeting the following criteria: a) 18 years or older, b) no heart disease or pacemaker implant, c) no physical or mental disease, d) no acute substance abuse	30	https://www-sciencedirect-com.uplib.idm.oclc.org/science/article/pii/S0197455617301405?via%3Dihub

4	psychophysiology AND music AND stress	ProQuest Agriculture Science	How Live Performance Moves the Human Heart	Haruka Shoda1¤*, Mayumi Adachi1, Tomohiro Umeda2	2016	Experimental	Seven pianists (2 men, 5 women, 24-40 years old, M = 30.57, SD = 6.46), who held a music degree in an undergraduate and/or graduate level, participated in this study. Each of 118 undergraduate and graduate students (53 men, 65 women) participated as an audience member for one of the live performances	7 pianists and 118 audience	https://www-proquest-com.uplib.idm.oclc.org/agriculturejournals/docview/1783674517/fulltextPDF/1DC60FF018744A1CPQ/6?accountid=14717

5	psychophysiology AND music AND stress	ProQuest Agriculture Science	Autonomic Effects of Music in Health and Crohn's Disease: The Impact of Isochronicity, Emotional Valence, and Tempo	Roland Uwe Krabs1¤a, Ronny Enk1¤b, Niels Teich2, Stefan Koelsch1,3*	2015	Experimental	randomly selected from an institutional database of healthy volunteers of the Max Planck Institute for Human Cognitive and Brain Sciences (health was assessed by interviews before acceptance into the database) aged 18 to 35 years)	157 participants (36 female,	https://www-proquest-com.uplib.idm.oclc.org/agriculturejournals/docview/1982583823/fulltextPDF/1DC60FF018744A1CPQ/18?accountid=14717
6	psychophysiology AND music AND stress	ProQuest Agriculture Science	Increase in salivary oxytocin and decrease in salivary cortisol after listening to relaxing slow-tempo and exciting fast-tempo music	Yuuki Ooishi1☯*, Hideo Mukai2,3☯, Ken Watanabe1,4, Suguru Kawato3, Makio Kashino1,4,	2017	Experimental	healthy males aged 21–34 years	26	https://www-proquest-com.uplib.idm.oclc.org/agriculturejournals/docview/1973446222/fulltextPDF/1DC60FF018744A1CPQ/33?accountid=14717

7	"psychophysiology" AND "music characteristics" AND "stress"	Google	A study of the type and characteristics of relaxing music for college students	Wei-Chun Wang	2014	Experimental	undergraduate students	297 (137 males and 160 females)	https://asa.scitation.org/doi/pdf/10.1121/1.4902001
8	"psychophysiology" AND "music characteristics" AND "stress"	Google	Effects of music interventions on stress-related outcomes: asystematic review and two meta-analyses	Martina de Wittea,b,c, Anouk Spruitd, Susan van Hoorenc,e,f, Xavier Moonend,eandGeert-Jan Stams	2019	Meta-analyses	Surgery, nonmedical, polyclinical, western and no-western	eseaer	https://www.researchgate.net/publication/333802379_Effects_of_Music_Interventions_on_Stress-Related_Outcomes_A_Systematic_Review_and_Two_Meta-Analyses#pf2
9	"psychophysiology" AND "music characteristics" AND "stress"	Google	Subjective Emotional Responses to Musical Structure, Expression and Timbre Features: A Synthetic Approach	Sylvain Le Groux1, Paul F.M.J. Verschure1	2012	Experimental	normal hearing university students	13	https://vbn.aau.dk/ws/portalfiles/portal/75169177/CMMR2012ProcceedingsFinal.pdf

10	"psychophysiology" AND "music characteristics" AND "stress"	Google	Affective and Cognitive Consequences of Temporal and Textural Aspects of Background Music	Austeja Tamaliunaite	2017	Experimental	Non musicians, 18-3 years	32	https://www.duo.uio.no/bitstream/handle/10852/57263/1/1-AFFECTIVE-AND-COGNITIVE-CONSEQUENCES-OF-TEMPORAL-AND-TEXTURAL-ASPECTS-OF-BACKGROUND-MUSIC-A-PUPILLOMETRY-STUDY.pdf
11	"psychophysiology" AND "music characteristics" AND "stress"	Google	Emotional and psychophysiological responses to tempo, mode, and percussiveness	Marjolein D van der Zwaag, Joyce HDM Westerink, Egon L van den Broek	2011	Experimental	employees at Philips Research, The Netherlands, mean age 26.3	32	https://scholar.google.ca/citations?view_op=view_citation&hl=en&user=QCLRwy4AAAAJ&citation_for_view=QCLRwy4AAAAJ:uWQEDVKXjbEC

12	psychophysiology AND music AND stress	Sage Journals Psychology of Music	Music and felt emotions: How systematic pitch level variations affect the experience of pleasantness and arousal	Lucas Jaquet, Brigitta Danuser, and Patrick Gomez	2014	Experimental	undergraduate students, 18-38 years	49	https://journals-sagepub-com.uplib.idm.oclc.org/doi/pdf/10.1177/030573561245658 3
13	psychophysiology AND auditory characteristics AND anxiety	Sage Journals Psychology of Music	What makes music emotionally significant? Exploring the underlying mechanisms	Patrik N. Juslin, László Harmat, Tuomas Eerola	2014	Experimental	university students, 20-61 years	20	https://journals-sagepub-com.uplib.idm.oclc.org/doi/pdf/10.1177/030573561348454 8
14	"psychophysiology" AND "music elements" AND "stress"	Google	THE EFFECTS OF MUSICAL TEMPO AND DYNAMIC RANGE ON HEART RATE VARIABILITY IN HEALTHY ADULTS	CC Stith	2015	Experimental	undergraduate students age 18-24	32	https://libres.uncg.edu/ir/asu/f/Stith%20Thesis.pdf

15	Effect of music on stress	Sage Journals Psychology of Music	What makes music relaxing? An investigation into musical elements	Eugenia Hernandez-Ruiz1 , Bianca James2, Jordan Noll2 and Evangelia G. Chrysikou	2020	Experimental	female students (age 18-27)	40	https://journals-sagepub-com.uplib.idm.oclc.org/doi/pdf/10.1177/0305735618798027
16	“psychophysiology" AND "music elements" AND "stress"	Google Scholar	Pilot Study Investigating the Efficacy of Tempo-Specific Rhythm Interventions in Music-Based Treatment Addressing Hyper-Arousal, Anxiety, System Pacing, and Redirection of Fight-or-Flight Fear Behaviors in Children with Autism Spectrum Disorder (ASD)	Dorita S. Berger	2011	Experimental	8-12 years old, lower to moderate on autism spectrum	6	https://connectinginrhythm.com/CIR/wp-content/uploads/2021/02/pilot-study-investigating-the-efficacy-of-tempospecific-rhythm-interventions-in-musicbased-treatment-addressing-hyperarousal-anxiety-system-pacing.2090-2719-1-104.pdf

17	“psychophysiology" AND "music" AND "anxiety"	Google Scholar	INVESTIGATING THE ISO PRINCIPLE: THE EFFECT OF MUSICAL TEMPO MANIPULATION ON AROUSAL SHIFT	Daniel Goldschmidt	2020	Experimental	Mean age 38.5	15	https://mountainscholar.org/bitstream/handle/10217/219516/Goldschmidt_colostate_0053N_16288.pdf?sequence=1&isAllowed=y
18	“psychophysiology" AND "music" AND "anxiety"	Ebsco host APA PsycInfo	Anxiety Reduction With Music and Tempo Synchronization on Magnetic Resonance Imaging Patients	Zsuzsa Földes, Esa Ala-Ruona, and Birgitta Burger Gergely Orsi	2017	Experimental	18-82 years, undergoing MRI scan between Jan 2016 and March 2016	60	http://web.b.ebscohost.com.uplib.idm.oclc.org/ehost/pdfviewer/pdfviewer?vid=0&sid=98667edd-1960-4509-b471-c9854a8e89c1%40sessionmgr103
19	Journal references		The Effect of Music Tempo on the Psychophysiological Measures of Stress	Briana Brownlow	2017	Experimental	18-22, UNDERGRADUATE	102	https://radar.auctr.edu/islandora/object/continuum%3A0001.002/datastream/OBJ/download

20	Journal references		Feelings and Perceptions of Happiness and Sadness Induced by Music: Similarities, Differences, and Mixed Emotions	Patrick G. Hunter, E. Glenn Schellenberg, and Ulrich Schimmack	2010	Experimental	UNDERGRADUATES	49	http://web.ebscohost.com.uplib.idm.oclc.org/ehost/pdfviewer/pdfviewer?vid=0&sid=81416209-e252-4bef-a808-1278ebdac180%40pdc-v-sessmgr03
21	Journal references		The Interplay of Preference, Familiarity and Psychophysical Properties in Defining Relaxation Music	Xueli Tan, Charles J. Yowler, Dennis M. Super, Richard B. Fratianne	2012	Experimental	Music therapists and haelthy adults	14 music therapistc and 80 adults	https://watermark-silverchair-com.uplib.idm.oclc.org

APPENDIX D

Data extraction tool

Title	Author	Year of publication	Sample size	Population age	Population gender	Population specification/ diagnosis	Sample country	Main objective	Physio-logical measurement relating to current study	Psycho-logical measurement relating to current study	Auditory characteristics
Psycho-physiological responses to auditory change	Chuen, L., Sears, D., & McAdams, S.	2016	80	Range= Not stated Mean age=22	40 males and 40 females	Adults with standard hearing levels	Canada	Whether simple types of auditory change that occur frequently during music listening could elicit measurable changes	Heart rate, SCR, respirartion rate	N/A	Tim bre, pitch, intensity, tempo

Autonomic and Psychophysiological Correlates of the Effects of Music Therapy in Neurotic Disorders	Kazymov, A. G., Mamedov, M., Alieva, D. M., & Chobanova, O. M.	2014	96 (48 per group)	Range= 15-18 years Mean age= Not stated	Not stated	Healthy adolescents and adolescents with neurotic disorders (generalised anxiety disorder and adjustment disorder)	Azerbaijan	study the age-related characteristics of the dynamics of psychophysiological correlates of the effects of medical resonance therapeutic music in healthy adolescents aged 15–18 years and patients with neurotic disorders of the same age group.	N/A	Situational anxiety and endogenous anxiety (Spielberger test) wellbeing, activity and mood (WAM test)	Tempo

Affective and autonomic response to dynamic rhythmic entrainment: Mechanisms of a specific music therapy factor	Kim, S., Gabel, C., Aguilar-Raab, C., Hillecke, T. K., & Warth, M.	2018	30	Range= Above 18 years Mean age= Not stated	Not stated	Heathy university students	Germany	to examine specific cardiovascular and affective effects of live music matched with the listener's heart beat, with the tempo gradually decreased to assess the relaxation effect.	Heart rate	Stress and well-being (visual analogue scales (VAS))	Tempo
How Live Performance Moves the Human Heart	Shoda, H., Adachi, M., & Umeda, T.	2016	37	**Pianists:** Range= 24-40 Mean age= 30.57 **Audience:** Range= 18-26 Mean age= 20.59	**Pianists:** 2 men and 5 women **Audience:** 16 men and 21 women	Pianists with a music degree (undergraduate or graduate level) Audience, undergrauate and graduate students	Japan	how the audience member's physiological reactions differ as a function of listening context (i.e., live versus recorded	HRV, heart rate	N/A	Tempo

								music contexts)			
Autonomic Effects of Music in Health and Crohn's Disease: The Impact of Isochronicity, Emotional Valence, and Tempo	Krabs, R. U., Enk, R., Teich, N., & Koelsch, S.	2015	30	Range= 18-35 Mean age= Not stated	13 males and 17 females	Healthy participants	Germany	assess the effects of different musical tempi (i.e., numbers of bpm) on ANS activity	Heart rate, HRV,	Emotional valence	Tempo
Increase in salivary oxytocin and decrease in salivary cortisol after listening	Ooishi, Y., Mukai, H., Watanabe, K., Kawato, S., &	2017	26	Range= 21-34 Mean age= 29.4	26 males	Healthy participants, with normal hearing	Japan	listening to relaxing slow-tempo and exciting fasttempo music is accompanied by	Heart rate, HRV	Emotional valence	Tempo

to relaxing slow-tempo and exciting fast-tempo music	Kashino, M.							increases in the oxytocin and cortisol levels, respectively			
A study of the type and characteristics of relaxing music for college students	Wang, W.	2014	297	Range= Not stated Mean age= Not stated	137 males and 160 females	University students	Taiwan	investigate correlation between music preference, music expertise, and degree of perceived relaxation-associated responses in music for college students.	N/A	stress, arousal and unpleasant (3-dimensional emotional responses)	Tempo
Effects of music interventions on stress-related outcomes: asystemati	de Witte, M., Spruit, A., van Hoorenc, S., Moonend,	2019	9617	Range= Above 18 years Mean age= N/A	N/A	N/A	N/A	To summarize the growing body of empirical research,	N/A	Stress	Tempo

c review and two meta-analyses	X., & Stams, G.										
Subjective Emotional Responses to Musical Structure, Expression and Timbre Features: A Synthetic Approach	Le Groux, S., & Verschure, P. F. M. J.	2012	13	Range= 22-31 Mean age= 25.8	8 males and 5 females	University students	Spain	validating the use of a synthetic music system to evoke and study emotional responses	N/A	Valence, arousal and dominance	Tempo
Affective and Cognitive Consequences of Temporal and Textural Aspects of Background Music	Tamaliunaite, A.	2017	32	Range= 18-35 Mean age= 29.03	15 males and 17 females	Non-musicians (students and staff of a university)	Norway	investigated whether increases in tempo are associated with greater self-reported arousal as well as greater tonic pupillary responses	N/A	Self-reported arousal and valence (Russel Affect Grid)	Tempo

								and if effects of tempo on both indices of arousal are moderated by the degree of percussiveness of the musical excerpt			
Emotional and psychophysiological responses to tempo, mode, and percussiveness	van der Zwaag, M. D., Westerink, J. H. D. M., & van den Broek, E. L.	2011	32	Range= Not stated Mean age= male 26.3 female 24.6	16 men and 16 women	Healthy participants	Netherlands	investigated the influence of the musical characteristics of tempo, mode, and percussiveness on our emotions	Skin conductance and HRV	Self-reported arousal and valence	Tempo
Music and felt emotions: How systematic pitch level variations affect the	Jaquet, L., Danuser, B., & Gomez, P.	2014	49	Range= 18-38 Mean age= 23.3	24 males and 25 females	Healthy participants (mainly undergraduate)	Switzerland	to assess the effect of systematic pitch variations on self-reports of	N/A	Self-reported arousal and valence	Pitch

experience of pleasantness and arousal								felt valence and arousal.			
What makes music emotionally significant? Exploring the underlying mechanisms	Juslin, P. N., Harmat, L., & Eerola, T.	2014	20	Range= 20-61 Mean age= 28	10 males and 10 females	Mainly university students	Sweden	study emotional reactions to music is to attempt to obtain direct links between musical surface features such as tempo and a listener's response	N/A	Emotional arousal	Tempo
The effect of musical tempo and dynamic range on heart rate variability in health adults	Stith, C. C.	2015	32	Range= 18-24 Mean age= 19.3	17 males and 15 females	University students	United States of America	to explore how different elements of music affect physiological responses	HRV, HR	Emotional valence	Tempo

What makes music relaxing? An investigation into musical elements	Hernandez-Ruiz, E., James, B., Noll, J., & Chrysikou, E. G.	2020	40	Range= 18-27 Mean age= 19.13	40 females	University students	United States of America	discriminate which musical element is responsible for the relaxation response	Heart rate, respiration rate, skin conductance	Self-reported arousal and valence	Tempo, timbre, intensity
Pilot Study Investigating the Efficacy of Tempo-Specific Rhythm Interventions in Music-Based Treatment Addressing Hyper-Arousal, Anxiety, System Pacing, and Redirection of Fight-or-Flight Fear Behaviors in	Berger, D. S.	2011	6	Range= 8-12 Mean age= Not stated	Not stated	Autism Spectrum Disorder (lower to moderate range)	United States of America	Investigating whether patterned, tempo-based, rhythm interventions, at 60-beats per minute (pbm), can regulate and induce systemic pacing, reduce repetitive anxiety behaviors and enable focus and calm in	Heart rate	N/A	Tempo

Children with Autism Spectrum Disorder (ASD)								persons with ASD.			
Investigating the Iso Principle: The effect of musical tempo manipulation on arousal shift	Goldschmidt, D.	2020	15	Range= over 18 years Mean age= Not stated	Not stated	Healthy adults	United States of America	to investigate arousal shift during iso principle-informed tempo change in a musical stimulus.	Skin conductance	Self-reported arousal (self-assessment manikin)	Tempo
Anxiety Reduction With Music and Tempo Synchronization on Magnetic Resonanc	Földes, Z., Ala-Ruona, E., Burger, B., & Orsi, G.	2017	60	Range= 18-82 Mean age= 47.18	27 males and 33 females	Patients undergoing MRI scans between January and March 2016	Hungary	Investigating whether listening to music during an MRI examination significant	N/A	Anxiety (State trit anxiety) and VAS measuring pleasantaneness/unplesantness of the MRI procedure	Tempo

e Imaging Patients								ly reduces patient anxiety,			
The Effect of Music Tempo on the Psychophysiological Measures of Stress	Brownlow, B.	2017	102	Range= 18-22 Mean age= 20	102 females	African-American female undergraduates	United States of America	to assess music tempo's role in stress reduction, utilizing psychophysiological measures.	Heart rate, skin conductance	N/A	Tempo
Feelings and Perceptions of Happiness and Sadness Induced by Music: Similarities, Differences, and Mixed Emotions	Hunter, P. G., Schellenberg, E. G., & Schimmack, U.	2010	49	Range= Not stated Mean age= Not stated	11 males and 38 women	University students	United States of America	Examining similarities and differences between listeners' perceptions of emotions conveyed by 30-s pieces of music and their emotional responses	N/A	Emotional arousal	Tempo

								to the same pieces.			
The Interplay of Preference, Familiarity and Psychophysical Properties in Defining Relaxation Music	Tan, X., Yowler, C. J., Super, D. M., & Fratianne, R. B.	2012	80	Range= 22-72 Mean age= 44.9	30 males and 50 females	Non-musicians	United States of America	The purpose of this study was to investigate the psychophysical properties associated with relaxation music and to explore the correlation between music familiarity, preference, and degree of perceived relaxation in music.	N/A	Self-rated degree of relaxation	Tempo