January 2018

Do Different Music Genres Differentially Affect Autonomic Activity? How Music and Sound Affect Autonomic Activity Aroused by Visual Stimuli

Andrew Manson

Eastern Kentucky University

DO DIFFERENT MUSIC GENRES DIFERENTIALLY AFFECT AUTONOMIC ACTIVITY? HOW MUSIC AND SOUND AFFECT AUTONOMIC ACTIVITY AROUSED BY VISUAL STIMULI

BY

ANDREW MANSON

THESIS APPROVED:

Chair, Advisory Committee

Member, Advisory Committee

Member, Advisory Committee

Dean, Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a Master of Science degree at Eastern Kentucky University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from these documents are allowable without special permission, provided that accurate acknowledgements of the source is made. Permission for extensive quotation from or reproduction of this document may be granted my major professor in his absence, by the Head of Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this document for financial gain shall not be allowed without my written permission.

Signature:

X

Date: 4/3/2018

DO DIFFERENT MUSIC GENRES DIFFERENTIALLY AFFECT AUTONOMIC ACTIVITY? HOW MUSIC AND SOUND AFFECT AUTONOMIC ACTIVITY AROUSED BY VISUAL STIMULI

BY

ANDREW MANSON

Submitted to the Faculty of the Graduate School of
Eastern Kentucky University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE
2018

Dedication

This thesis experiment is dedicated to my friends and family.

Abstract

The primary researcher sought to determine whether different genres of music would differentially influence measures of autonomic nervous system activity (heart rate, galvanic skin response) while viewing visual stimuli in a sample of college students. All participants listened to the same songs and music genres and viewed the same International Affective Picture System (IAPS) images. Autonomic nervous system activity was recorded by attaching electrodes to participants' non-dominant hand and torso. Music order presentation and picture order presentation were randomly determined by E-Prime. Heart rate and skin conductance responses were both significant, with melodic metal music inducing greater intensity of responses for both, and an interaction effect was revealed for heart rate minimum and picture type. Findings show that different genres of music differentially affect autonomic nervous system activity, and that these effects are further influenced by stimuli valence (positive, negative, neutral). These results reveal that different genres of music have different effects on autonomic nervous system activity, and that such effects cannot be explained by musical preference.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

Introduction

The research question the current thesis project seeks to investigate is whether listening to different types of music and sound is capable of influencing ANS activity is indicative of emotional states (e.g., arousal and relaxation) during a visual task. Previous research has established that people often listen to music to regulate their mood (as cited in Patel, 2010, p. 315), and a multitude of studies have found that different types of music are capable of influencing ANS activity as indexed by physiological measures (for reviews see Ellis & Thayer, 2010; Salimpoor & Zatorre 2013). While the previously cited studies demonstrated that different types of music are capable of influencing both individuals' heart's electrical activity and EA, almost all music used in such studies was defined as belonging to one of two dichotomic categories (e.g., happy VS sad, relaxing VS stimulating, consonant VS dissonant). Consequently, there is a dearth of knowledge when it comes to which specific elements of both music (e.g., acoustics, percussion, keyboards) and sound (e.g., tone, timbre, rhythm) are capable of influencing ANS activity, and the type of influences such elements of both music and sound may have on ANS activity.

One type of music that has been correlated with influencing ANS activity is CM (e.g., J.S. Bach, Mozart, Erik Satie) (Baumgartner, Esslen, & Jäncke, 2006; Thoma et al., 2007). Other types of music that have yet to be systematically tested in their ability to influence ANS activity are MMM (see Animals as Leaders, Jeff Loomis) and AEM (see

Tycho, Emancipator). Melodic metal music is similar to other types of metal music (i.e., heavy metal music) that have been sparingly tested in empirical studies (see Yamamoto, Naga, & Shimizu, 2007), as well as rock music, which has also been empirically tested in its ability to influence ANS activity to a greater extent (Burns et al., 2002; Carpentier & Potter, 2007). While AEM is also similar to other types of music – in this case electronica music – the only type of electronica music to be empirically tested in its ability to influence ANS activity is "trance" music (see Dousty, Daneshvar, & Haghjoo, 2011).

Ambient electronic music artists draw from various genres of music to create AEM in a multitude of ways. Because AEM utilizes elements of music that are commonly found in other types of music (e.g., string instruments, keyboard arrangements, percussion elements), AEM is able to be manipulated to a far greater extent than both classical and most if not all other types of music. This is due to AEM utilizing sound synthesizers that allow for both substantial manipulation and the incorporation of a multitude of music and sounds. For example, sound synthesizers are able to isolate specific parts of songs for the purpose of a) looping such parts or song bits, b) manipulating characteristics of song bits such as wave frequency and the timbre of specific musical instruments, c) increasing or decreasing parts of song bits to simulate crescendo or decrescendo effects, d) adding or removing specific musical instruments while holding other musical instruments constant, e) combining song bits with other isolated song bits to produce mash-up effects, and f) other things that are beyond the scope of this thesis. Additionally, all of the previously mentioned manipulations can be done by a single person utilizing a computer and the necessary computer software.

Because sound synthesizers are capable of enhancing or diminishing specific elements of all types of recorded music, AEM is an excellent choice for investigating whether the act of listening to music can influence ANS activity, specifically whether listening to music can decrease ANS arousal.

Music and Sound, and Why Ambient Electronic, Heavy Metal, and Classical Music?

Joshua Leeds' The Power of Sound (2001) and Daniel Levitin's This Is Your Brain On Music (2006) are substantial works of discourse in terms of discussing how people react to both music and sound, and how music and sound influence the autonomic nervous system (ANS) in different ways. For example, music that people are fond of can create peak emotional experiences, which in turn create memory-based psychological reactions (Leeds, 2001). In addition, slightly detuned tones can cause human brain waves to slow down or speed up (Leeds, 2001). Furthermore, while music causes us to experience psychological responses, primary effects of such responses are physiological or neurological in nature (Leeds, 2001).

Leeds (2001) defines basic concepts of music as *frequency*, *sound* itself, *pitch*, *timbre*, and *loudness*/*volume*/*amplitude*, while Levitin (2006) defines supplemental concepts as *rhythm*, *tempo*, and *contour*. For definitions of the previously mentioned musical terms, see Table 1[1]. Additionally, Leeds contends that music influences the performance of the ANS mostly due to entrainment, a process which – in the context of psychoacoustics – concerns altering the pace of brain waves, breaths, or heart-beats from one speed to another (Leeds, 2001). Furthermore, Leeds makes two more points that support utilizing types of music that have yet to be systematically tested in their ability to

[1] Tables are listed in Appendix A, figures are listed in Appendix B

influence ANS activity for the current thesis project. According to Leeds (2001), high tones charge the ANS while low tones discharge the ANS, and "music has strong effects on behavior and can do so by communicating moods and emotions…music can rapidly and powerfully set moods and do so in a way not as easily attained by other means". Consequently, types of music that have yet to be systematically tested in their ability to influence ANS that the current thesis project utilized are melodic metal music (MMM) and ambient electronic music (AEM), as high tones are quite frequent in both MMM and AEM, whereas another type of music that has been systematically tested in its ability to influence ANS that the current thesis project utilized is classical music (CM).

Defining Psychophysiological Measures

One issue of psychophysiological research and literature is that certain terms are used interchangeably to describe the same concept or measure. To avoid creating this sort of confusion, this section briefly defines some basic psychophysiological terms that are continuously referenced throughout the current thesis project.

Electrical activity produced by the human heart is measured through use of an electrocardiogram or EKG/ECG. While an ECG contains many different elements that characterize the heart's electrical activity, certain major ECG elements include R waves and T waves. Specifically, R waves refer to the depolarization of the ventricles, while T waves refer to repolarization of the ventricles (Stern, Ray, & Quigley, 2001). Furthermore, the amplitude and latency of these types of waves are often analyzed to draw conclusions about more broad measurements, such as minimum/maximum heart rate (HR) and decreases/increases in HR.

Electrodermal activity (EA) or the galvanic skin response can be described in four different ways, which include *skin conductance level* (SCL), *skin conductance response* (SCR), *skin potential level* (SPL), and *skin potential response* (SPR), while baseline EA is referred to as *tonic* activity and EA that is generated in response to a stimulus is referred to as *phasic* activity (Stern et al., 2001). Specifically, the word level is used when referring to tonic EA, while the word response is used when referring to phasic EA (Stern et al., 2001). Furthermore, SCL is defined as "the reciprocal of skin resistance level", whereas SCR is defined as "the reciprocal of skin resistance response", whereas SPL is defined as a "measure of electrical activity at the surface of the skin when the organism is in a state of rest…", whereas SPR is defined as a "measure of electrical activity at the surface of the skin when the organism is responding to a specific stimulus" (Stern et al., 2001, p. 272).

Chapter 2

Literature Review

A substantial body of research has examined the music's influence on psychophysiological measures of ANS activity (Baumgartner et al.2006; Burns et al., 2002; Carpentier & Potter 2007; Coutinho & Cangelosi 2011; Dousty et al., 2011; Gomez & Danuser 2007; Khalfa, Roy, Rainville, Dalla Bella, & Peretz, 2008; Olsen and Stevens 2007; Sammler, Grigutsch, Fritz, & Koelsch, 2007; Sokhadze, 2007; van der Zwaag, Westerink, & van den Broek, 2011; Yamamoto et al., 2007). Two measures of ANS activity that are commonly used to gauge whether stimuli influence ANS activity are heart rate (HR) and SCR. Heart rate and SCR are both non-invasive, reliable, and easy to obtain, and thus are ideal for assessing how different types of music influence psychophysiological emotion and arousal systems. The following literature review details previously cited research as well as other relevant studies, and is chronologically organized by type of variable(s) assessed. More specifically, the first four studies discuss examined aspects of HR, whereas the following three studies discuss examined aspects of EA, whereas the remaining ten studies discuss examined aspects of both HR and EA. Lastly, all studies cited in the current thesis's literature review utilized music that was instrumental and did not contain vocals.

Studies of Heart Rate

Do hard rock, classical, or self-selected types of music differentially influence individuals' HR? Burns et al. (2002) recruited sixty undergraduate students between eighteen and forty-nine years of age from psychology courses at a regional university in southern Alabama. Participants were randomly assigned to three different music groups (hard rock, self-selected, and classical) and one control group (silence). Burns et al. (2002) recorded participants' heart rate with a J&J Module P-401 with a plethysmograph placed on the ventral side of participants' right hand's middle finger. Recording of participants' ANS activity began with participants sitting in a recliner in silence for ten minutes for the purpose of obtaining baseline physiological recordings. Next, participants listened to music for ten minutes while having their physiological activity recorded, which was followed by sitting in silence for an additional ten minutes while having their physiological activity recorded. The control group had their heart rate recorded at the same times as participants in other groups, though they simply sat in silence for thirty minutes. Results showed that a) participant heart rate during the final recording was lower than the first recording for the classical music group, b) participant heart rate during the final recording was lower than both the first and second recordings for the rock music group, c) participant heart rate increased with each recording for the self-selected music group, and d) participant heart rate was highest during the second recording and lowest during the first recording for the control group. With these results in mind, Burns et al. (2002) found that participants' heart rate was significantly influenced by all types of music (hard rock, classical, self-selected).

Is heart rate differentially influenced by consonant and dissonant music? To investigate this possibility, Sammler et al. (2007) had participants sit comfortably while listening to different types of music and having their HR measured, with different types of music being categorized as either "consonant" or "dissonant". Sammler et al. (2007)

recruited eighteen students between twenty and thirty years of age in an experiment that investigated whether consonant and dissonant music differentially influenced EEG power spectra and HR. Participants were classified as non-musicians and had no formal music training and played no musical instruments. Musical stimuli utilized in this experiment included consonant musical pieces consisting of ten excerpts of joyful instrumental dance tunes from the past four centuries and dissonant musical pieces consisting of electronically manipulated counterparts of the consonant excerpts. Specifically, dissonant musical excerpts were created using Cool Edit Pro (Syntrillium) software, with dissonant musical excerpts being one tritone below and one tone above their consonant counterparts. Furthermore, each musical stimulus had an average length of approximately one minute and average tempo of 120 beats per minute.

Sammler et al.'s (2007) experiment included baseline trails that consisted of periods of silence for thirty seconds, which were followed by one minute presentations of either consonant or dissonant pieces of music. Results showed that a) participant HR initially decreased (within the first second) for both types of music, which was thought to reflect the orienting response, which was followed by b) a HR acceleration that was greater for consonant than for dissonant excerpts as well as a secondary deceleration of HR (within the first eight seconds), c) HR during dissonant excerpts remained lower than during consonant pieces, d) there was an even greater decrease in HR during the second half of dissonant excerpts (compared to the first half), while HR remained steady for the duration of consonant excerpts, and e) HR deceleration and participant discomfort while listening to music was significantly linearly correlated. Consequently, Sammler et al.'s

(2007) experiment demonstrated that consonant and dissonant music differentially influenced participants' HR.

Can music have positive effects on clinical symptoms? Chan, Chan, Mok, and Tse (2009) sought to assess how music may influence depression levels and physiological responses of community-based older adults. In their study, Chan et al. divided forty-seven elderly people of ages sixty to eighty plus into two groups (music intervention and no music intervention group) and over the course of four weeks recorded autonomic measures and depression level variables. More specifically, week one consisted of recording baseline demographic, physiological, and psychological data, with physiological and psychological data being recorded in weeks two through four (data was recorded once per week). Chan et al. (2009) gave music intervention group participants the option of choosing between four types of music, with participants listening to their chosen type of music for approximately thirty minutes once per week with sessions taking place either at a day-care center or at participants' homes. Participants were briefed on how to conduct their music sessions appropriately, and the four types of music consisted of Western classical (*Beethoven's Symphony No. 5*), Western jazz (*April in Paris, Dreamsville*), Chinese classical (*TAO, Lord of Wind*), and Asian classical *(Everlasting Road*). Furthermore, the tempo of each musical piece was between sixty to eighty beats per minute and contained no accented beats, percussive characteristics, or syncopation. Concerning Chan et al.'s (2009) findings, while both groups showed no significant differences in HR after the baseline week and week two, the music intervention group showed a significant progressive decrease in HR compared to the no music intervention group during weeks three and four. Furthermore, the no music intervention group showed a statistically significant increase in depression score at week four compared to baseline, whereas the music intervention group showed a statistically significant decrease in depression score at week four compared to baseline.

Does sedative and arousal music have different effects on heart rate compared to silence? Dousty et al. (2011) investigated whether “sedative music”, “arousal music”, and silence had different effects on individuals’ electrocardiography (ECG) recordings. Participants consisted of thirty-two healthy students between nineteen and twenty-four years of age (gender not included, mean age = 22.1±1.6 years) from the Sahand University of Technology. Each participant had their ECG data recorded for three minutes, which was done while they lay on a bed with their eyes covered by an eye patch to increase their ability to concentrate on the music. In addition, participants were instructed to not think about anything while having their ECG data recorded and to just listen to the music. Each three-minute ECG consisted of thirty seconds of silence, sixty seconds of sedative music, thirty seconds of silence, and fifty-two seconds of arousal music. Each type of music was adjusted to from -72 dB and reach -18 dB within four seconds to reduce the instantaneous response of an enhanced sympathetic tone caused by a heightened attention level. Furthermore, the ECG sample rate was set to 1 KHz, and the correct pattern was used for estimating the amount of the R wave, T wave, and P wave. Lastly, to calculate the HR, R waves were marked with the distance between the R waves calculated and entered into the formula (HR = 60/R wave to the next R).

Sedative music was played by piano at a rate of nineteen beats per minute, while arousal music was defined as “trance” music – which is a type of electronic music – and contained 120 beats per minute. Dousty et al.’s (2011) experiment was organized into four comparison phases: a) silence – sedative, b) silence – arousal, c) arousal – sedative, and d) music irrespective of type – silence. Significant findings for phase one through four include minimum R wave amplitude and minimum and maximum HR; minimum R wave amplitude and maximum T wave amplitude; mean R wave amplitude and maximum HR; and mean and minimum R wave amplitude and minimum and maximum HR. Regarding the nature of these findings, R waves are large upward deflections that reflect ventricular depolarization, whereas T waves are minor upward deflections that reflect ventricular repolarization (Ashley & Niebauer, 2004). In summarizing their findings, Dousty et al. concluded that amplitudes of repolarization and depolarization can vary in response to different types of music, and thus sedative and arousal music stimulate the heart in different ways. Specifically, sedative music induced higher mean R-wave amplitude than arousal music, and arousal music influenced T-wave maximum amplitude (Dousty et al., 2011).

Does music have differential effects on individuals' HR based on their age? Hilz et al. (2014) investigated whether autonomic responses to music-onset may differ between people of different ages, which was similar to Chan et al.'s (2009) study in that both Hilz et al. (2014) and Chan et al. (2009) recruited elderly participants (i.e., sixty-plus years of age). Participants consisted of ten young and ten older healthy volunteer, while music utilized for the experiment consisted of "relaxing" and "aggressive" music. Specifically, "relaxing" music consisted of excerpts from Ferrucio Busoni's *Turandot Suite, Turandot's chamber* and from N. Rimsky-Korsakov's *Shéhérazade, The Young Prince and the Young Princess*, whereas "aggressive" music consisted of excerpts from Igor Starvinsky's *The Rise of Spring, Ritual Action of the Ancestors* and from Béla

Bartòk's *The miraculous Mandarin, Suite, Op. 19*. Regarding the experimental design, participants rested for thirty minutes in supine position in a quiet room, then listened to the four previously mentioned musical excerpts, with five minutes of quiet relaxation periods in-between each musical excerpt. Participants had many autonomic measures recorded during the experiment (e.g., HR, respiration, blood pressure), and while HR was measured in numerous ways (e.g., RRI oscillations, RRI-total-powers, RRI-low frequency/high frequency ratios), the most significant measurement recorded was interbeat intervals (RRI), which is determined by gauging the time between R waves (Stern et al., 2001). Furthermore, the onset of both relaxing and aggressive music significantly lowered older participants' RRI, thus demonstrating that when comparing baseline HR to HR during the first thirty seconds of listening to music, the presentation of both relaxing and aggressive music significantly increased older participants' HR. Alternatively, neither presentation of relaxing or aggressive music significantly influenced younger participants' RRI and thus HR. Thus, both relaxing and aggressive music significantly influenced aspects of older participants', but not younger participants' HR. In conclusion of the previously discussed studies, different types of music can differentially influence measures of individuals' HR.

This subsection's previously discussed studies investigated how music influenced heart rate. All discussed findings proved to be consistent. Heart rate was found to a) increase during the experience of listening to self-selected music and be differentially influenced by different types of music (rock, classical, self-selected) (Burns et al., 2002), b) exhibit greater increases for consonant music than for dissonant music and greater decreases over time for dissonant music while consonant music kept heart rate steady over time (Sammler et al., 2007), c) exhibit a significant progressive decrease over time for music intervention group participations compared to no music group participants (Chan et al., 2009), and d) experience higher mean R-wave amplitude for sedative music than for arousal music, while arousal music influenced T-wave maximum amplitude compared to sedative music (Dousty et al., 2011).

Studies of Skin Conductance

Can both aspects of music and different music genres differentially influence measures of individuals' skin conductance? Carpentier and Potter (2007) sought to investigate whether tempo (fast, slow, silence) and music genre (rock, classical, swing music) would differentially affect participants' ANS activity as measured by both SCR and SCL by designing two separate experiments. Participants consisted of twenty-five university students (gender and age not listed), though SCR data was only obtained for eighteen participants due to equipment malfunction.

Experiment one utilized a mixed-measures design with fast, slow, and silent tempos, as well as rock and classical music, with the between-subjects variable designated as order of presentation. Once participants were familiarized with the procedure and had electrodes attached to their non-dominant hand they viewed a single segment on a television screen, which consisted of a brief musical selection or silence followed immediately by a short film clip. Additionally, the television screen was turned off/black during the music/silence part of each segment. Furthermore, the experimenter paused both the videotape and physiological data collection after the conclusion of each segment to allow each participant to answer evaluation questions of the film clip. Once participants had completed answering questions, their physiological activity was allowed to reset to baseline levels and the experimenter resumed stimuli presentation and data collection. This procedure was carried out for a total of six segments. Consequently, multivariate analysis (MANOVAs) revealed that a) SCR frequency was higher and almost identical for both rock and classical music in comparison to silence, b) an interaction effect between tempo (fast and slow) and genre that showed higher SCR frequency for slow rock music and fast classical music with lower SCR frequency for fast rock music and slow classical music, and c) fast music induced higher SCL changes that generally increased over five second segments while slow music induced lower SCL changes that generally decreased over five second segments.

Though experiment two was similar to experiment one, one key difference was that the silence group was replaced with a swing music group. This time multivariate analysis showed that SCR frequency for both fast and slow music was highest for classical and lowest for swing music, while fast music induced an increase in SCR frequency for classical music and decreases in SCR frequency for rock and swing music. Furthermore, SCL changes were unique for each kind (classical, rock, and swing music) of both fast and slow music. Over five second segments, participants' SCL changes for slow classical music were highest and showed a very slight decline, while fast classical music showed an initial sharp followed by steady decline; for both fast and slow rock music, participants' SCL changes showed an identical steady decline; lastly, for both fast and slow swing music participants' SCL changes showed a steady decline, though fast swing music showed an initial rise in SCL changes that was followed by a steady decline. Taking Carpentier and Potter's (2007) results into consideration, both tempo and music genre differentially influenced measures of participants' skin conductance, both individually and in combined interaction effects.

How does loudness influence measures of individuals' skin conductance? Olson and Stevens's (2013) study investigated how psychological and psychophysiological components of arousal and emotion respond to a violin chord stimulus characterized by continuous increases (up-ramp) or decreases (down-ramp) of intensity. Participants consisted of forty-five adults (eleven males, thirty-four females) between eighteen and forty-six years of age who were recruited from the University of Western Sydney. Experimental stimuli consisted of either a linear intensity increase (up-ramp) or decrease (down-ramp) from sixty to ninety decibels (dB) sound pressure level (SPL) and ninety to sixty dB SPL, respectively. Concerning violin stimuli, generation began with a 1.8 second and 3.6 second steady-state recorded violin sample, with each of the four violin stimuli including variable durations of silence between the range of ten to twelve seconds being presented at the beginning, with one second of silence added to the end of each stimulus. Furthermore, these periods of silence were combined with an approximate response time of three seconds for the computer-based loudness task, which resulted in mean intertrial intervals of fifteen seconds with a range of fourteen to sixteen seconds.

Olson and Stevens (2013) measures participants' ANS activity by attaching electrodes to the medial phalanges of participants' index and fourth fingers (non-dominant hand). Participants then received computer instructions that asked them to listen to each sound per trial and rate the perceived magnitude of loudness change on a computer-based visual analogue scale ranging from "no-change" to "large change", with a "moderate-change" in loudness as the midpoint of the scale. SCR was recorded throughout the experiment while participants completed the loudness perception task. In addition, each of the four stimuli was presented in a pseudorandom sequence in two separate but continuous blocks. Thus, eight trials in total were presented to each participant.

With relative dependent variables being loudness change and SCR, Olson and Stevens (2013) found that loudness change was significantly greater for an increase in loudness change – in terms of SPL, sixty to ninety decibels dB – compared to a decrease in loudness change (ninety to sixty dB). Additionally, loudness of change was significantly greater for longer (3.6 seconds) than shorted (1.8 seconds) violin chords. Furthermore, increases in loudness change induced SCR magnitudes of decreased intensity, as well as longer SCR rise times. Lastly, SCR magnitude was significantly increased for decreases in loudness of change compared to increases in loudness of change. Thus, Olson and Stevens (2013) found that different types of loudness change can differentially influence individuals' SCRs.

Can different aspects of music influence individuals' SCRs in a predictable manner? Tsai, Yang, Chen, Chen, and Liang (2015) conducted a study in which they had participants listen to music for the purpose of attempting to suppress participant SCRs. Participants consisted of thirty-eight non-musicians who were recruited through an Internet advertisement, with the majority of participants consisting of undergraduate students. Regarding what time of music was utilized, Tsai et al. first selected 135 musical excerpts for the purpose of encompassing a wide range of emotions thought to be induced from listening to specific excerpts. Types of musical excerpts ranged from Western Classical music and jazz music to Chinese music, with no excerpts being drawn from popular music or movie soundtracks. Each excerpt was between fifteen and thirty seconds in duration and was rated by 4,799 volunteer listeners in terms of which emotions were thought to be induced by each excerpt. More specifically, each excerpt was rated as being able to express one of eight categories of emotion (fun, happiness, tenderness, surprise, sadness, fear, anger, desire to move the body). Tsai et al. (2015) chose two excerpts for each intensity (low, medium, high) of expressed emotions, and divided these excerpts into two sets of stimuli (A and B), with each set consisting of twenty-four excerpts (three intensities of each emotion).

Participants were divided into two groups and listened to either set A or set B of musical excerpts. Additionally, no excerpt contained comprehensible lyrics, though two excerpts contained a voice that spoke meaningless syllables. Regarding the experimental design, participants sat individually in a comfortable armchair in a sound-attenuated room while having their baseline SCR measured for three minutes. Each participant did three experimental runs, with each run starting with a thirty-second rest period followed by eight trials. Each of the eight trials were one minute in length and consisted of a warning tone, a musical excerpt, and silence during which time participants were instructed to rate each excerpt on a five-point scale in terms of both preference and emotion intensity as previously determined by the 4,799 volunteer listeners. Furthermore, during presentations of musical excerpts participants were asked to close their eyes and focus on the music. Presentation order of the three experimental runs were counterbalanced across participants in both groups. Summarizing Tsai et al.'s findings, seven of the forty-eight selected musical excerpts briefly reduced SCR magnitude to below baseline SCR levels, whereas music analysis revealed that musical excerpts were likely to reduce SCRs if they

a) caused participants to anticipate sudden accents, which in turn caused participants to relax, b) evoked feelings of tenderness in participants or contained relaxing harmonic progressions, or c) contained repetitious musical rhythms or phrases.

This subsection's previously discussed studies investigated how music influenced skin conductance response. All discussed findings proved to be consistent. Skin conductance response was found to a) exhibit i) higher frequency for rock and classical music compared to silence, ii) higher frequency for slow rock and fast classical music compared to fast rock and slow classical music, iii) higher changes for SCL for fast music compared to lower changes for SCL for slow music, iv) SCR frequency was highest for fast and slow classical music and lowest for fast and slow swing music, and v) SCR frequency increased for fast classical music and decreased for fast rock and swing music; b) decrease in intensity and increase in rise times for increases in loudness change, but increase in intensity for decrease in loudness of change (Olson & Stevens, 2013); and c) reduce from anticipation of sudden accents, evoked feelings of tenderness, relaxing harmonic progressions, and repetitious musical rhythms or phrases (Tsai et al., 2015).

Studies of Heart Rate and Skin Conductance

Does music influence multiple measures of ANS activity? Baumgartner et al.'s study (2006) was the first emotional brain study that investigated how visual and musical stimuli influence brain processing, as well as psychophysiological measures such as SCR and HR. Participants consisted of twenty-four right-handed females, most of whom were students of psychology, biology, or medicine. It is worth noting that Baumgartner et al. (2006) intentionally recruited only females as participants due to females' tending to display stronger emotional reactions than males.

Utilizing highly arousing pictures of the IAPS and choosing classical music excerpts of exactly seventy seconds in length that were hypothesized to evoke the three basic emotions of happiness, sadness, and fear, Baumgartner et al. (2006) presented female subjects with emotional stimuli modalities in a counterbalanced and random order, with emotional stimuli modalities consisting of IAPS pictures, classical music excerpts, and both IAPS pictures and classical music excerpts. Each musical excerpt was taken from classical orchestral pieces that included Mars – *the Bringer of War* from *The Planets* (Gustav Holst), *Adagio for Strings* (Samuel Barber), *Symphony no. 6 (3rd mvt)* (Beethoven). Additionally, Baumgartner et al. (2006) had the beginning (first two seconds) and end (last two seconds) of each stimulus fade in and out, respectively to avoid startling participants, and only chose IAPS pictures that contained humans or human faces, with mean ratings for the three pictures categories as follows: *valence* = 2.20$\pm$0.76 (fear picture), 3.30$\pm$0.69 (sadness picture), 7.80$\pm$0.70 (happy picture); *arousal* = 6.50$\pm$0.94 (fear picture), 5.20 $\pm$0.84 (sadness picture), 6.10$\pm$0.81 (happy picture). While Baumgartner et al.'s study had numerous findings, relevant findings included that a) there was a significant main effect of modality, meaning that music significantly enhanced participants' emotional experience induced by affective pictures, b) SCR showed a tonic increase for the combined condition in comparison to the classical music excerpt condition, and c) SCR showed a significant main effect for emotion, as demonstrated by lowered SCRs in the happy condition compared to the negative emotional condition.

How do psychoacoustic features of music influence ANS activity? Gomez and Danuser's (2007) study is comparable to Baumgartner et al.'s (2006) study in that it also utilized classical music, and assessed many different variables that included, but were not limited to – mode, harmonic complexity, rhythmic articulate on, tempo, accentuation, positive and negative valence, HR, and SCL. Participants consisted of thirty-one individuals between eighteen and thirty-seven years of age. Furthermore, participants' SCL and HR were measured through use of the Varioport Measurement System. Lastly, Gomez and Danuser's experimental procedure was identical to an earlier study of theirs that investigated how environmental noise and music influenced participants' affective and physiological responses (see Gomez and Danuser, 2004).

Participants were informed that sixteen noises and sixteen musical passages, each thirty seconds in length would be played in random order, and that they should fully attend to each stimulus for the complete duration of presentation. Participants were also informed that they would report how they felt while listening to each noise or musical segment immediately after each noise or segment was presented, with strong emphasis on reporting how they actually felt while they listened to each stimulus. Additionally, participants reported how they felt (e.g., arousal and valence levels) by answering the pencil-and-paper version of the nine-point Self-Assessment Manikin (SAM). Furthermore, participants heard each noise or musical segment with sixty-five seconds of silence between each stimulus presentation. In conclusion, Gomez and Danuser (2007) analyzed their data through multiple regression and other types of analyses, with significant findings being that high SCL changes were positively correlated with fast tempo, and that high HRs were also positively correlated with fast tempo.

What happens to ANS activity when individuals are exposed to temporary stressors while listening to music? Sokhadze's (2007) study is similar to Gomez and

Danuser's (2007) study (both studies had participants listen to instrumental music) and may have been the first of its kind to see whether music could influence participants' ANS activity in the context of participants' ANS activity returning to baseline after experiencing a temporary stressor. In a study that assessed various physiological measures such as SCR, SCL, HR, and high/low frequency HR, Sokhadze administered three different genres (pleasant and sad music, white noise) after participants viewed pictures from the IAPS. Participants consisted of twenty-nine undergraduate college students, all of whom were females between twenty and twenty-four years of age.

After being introduced to the experiment and being hooked up to electrodes, participants sat in a reclining chair for ten minutes for adaptation and baseline recording. The experimental procedure included three sessions, each of which was divided into three phases which included a) a pre-stimulation resting baseline recording phase which lasted one minute, b) a visual stimulation phase with IAPS pictures that consisted of three IAPS slides with mutilated bodies that were each displayed for twenty seconds, and c) a two-minute auditory stimulation and post-stimulation resting baseline phase that lasted which lasted for one minute. In addition, one session consisted a set of three IAPS pictures (IAPS #1113, #3051, #3170) which were followed by "pleasant" music ("Spring song" by Victor Musical Industries, Ltd., Japan), while another session consisted of a different set of three IAPS pictures (IAPS #3140, #1300, #1120) which were followed by "sad" music ("Canon" by Johann Pachelbel, The Music Therapy Charity, Warner Classics, UK), while another session consisted of another different set of three IAPS pictures (IAPS #3071, #1301, #3130) which were followed by white noise (20 Hz – 20 KHz, 55dB). Furthermore, IAPS pictures were chosen on the basis of a preliminary study in which ninety college students used the SAM and a separate scale that measures disgust (see Lee et al., 1997), and normative means for the chosen IAPS pictures (arousal, valence, dominance) for females, which were 6.57 ± 0.64, 2.30 ± 0.94, and 3.6 ± 0.40, respectively. In conclusion, Sokehadze's major findings were that a) participant SCR and SCL increased in response to viewing pictures, b), participant HR decreased in response to viewing pictures, c) pleasant music caused participant HR to further decrease after its initial decrease which was followed by an increase in HR post-music presentation, d) sad music caused participant HR to rise after its initial decrease, which was followed by a second decrease in HR post-music presentation, and e) white noise caused participant HR to slightly increase after its initial drop, which was followed by a second increase post-white noise presentation.

What kind of relationships can be identified between music, mood, and stress? Yamamoto et al.'s (2007) study manipulated the relationship between affective valence and psychophysiological arousal by focusing on how mood is influenced by high-tempo (HT) and low-tempo (LT) music on both a high- and low-arousal stressful task condition (HST, LST). Participants for experiment one included twenty health university students (two males, eighteen females, mean age 25.4 years) who were divided into four small groups that were randomly assigned to a combination that consisted of one of two tasks (HST and LST groups) and one of two types of music (HT and LT music groups). Participants for experiment two included twenty healthy university students (five males, fifteen females, mean age 23.1 years) who did not participate in experiment one. Experiment two's design was identical to experiment one in that participants were also divided into four small groups that were randomly assigned to a combination consisting of HST and LST group tasks and HT and LT music groups. The HT music group conditions consisted of heavy metal (e.g., Megadeth and Steve Vai) and classical music (Mozart and Rossini), while the LT music group conditions consisted of jazz (e.g., Bill Evans and John Coltrane) and classical music (e.g., Debussy and Bach).

Concerning the LST, participants viewed a random sequence of numbers that included one through nine appear on the computer screen, with participants being instructed to push the computer mouse button rapidly each time the number two appeared on the screen. Concerning the HST, participants answered addition and subtraction problems that a) used one- or two-digit numbers, b) allowed participants four seconds to answer, c) were equivalent to second grade math problems, and d) caused a buzzer to ring from the computer if answered incorrectly of left unanswered. Also for the HST, if participants answered three questions incorrectly/ran out time before answering three questions a small car with needles placed on a wooden plate on its front moved five centimeters forward toward a big balloon at the end of a plate, which the car would reach if a participant either ran out of time before answering or answered twenty-four questions incorrectly. Lastly, both LST and HST conditions were performed for approximately twenty minutes.

Yamamoto et al. (2007) took various types of recordings while participants carried out the experimental tasks (e.g., salivary samples and psychophysiological measurements). Relevant findings were that LT music both significantly reduced HR levels of participants who carried out the experiment's HST and had stress-distractive effects on participants in both the HST and LST condition. Furthermore, 3 x 2 ANOVA analysis from experiment two indicated that the LT music groups produced stress-distractive effects for both task conditions, whereas the HT music group produced stress-distractive effects for the HST condition. Lastly, results from experiment two also indicated that the combination of transitioning from performing a task to listening to music and the consequent ten-minute rest condition produced arousal-moderating musical effects for all stressful conditions.

How are music genres defined by emotion and psychoacoustic variables related in their influence on ANS activity? Khalfa et al.'s (2008) study is comparable to Yamamoto et al.'s (2007) study, as both studies investigated whether two separate types of music that differed in tempo could influence physiological measures. Participants consisted of fifty healthy volunteers (twenty-nine men, twenty-one women, mean age 21.6±2.7 years) who were recruited among students at the University of Montreal. Musical excerpts chosen for this study included original versions of six musical excerpts (*Adagio* from Albinoni; *Concerto d'Aranjuez* from Rodrigo; *Peer Gynt's Suite n°2* from Grieg; *Carnaval des animaux (Finale)* from Saint-Saens; *Concerto n°23 (3rd mvt)* from Mozart; and *Eine kleine Nachtmusik (1st mvt)* from Mozart; each piece of fifteen seconds in mean duration) from a classical musical repertoire that had been used from a previous study (see Peretz Gagnon, & Bouchard 1998). Three of the six chosen musical excerpts had been established to convey happiness, with another three of the six chosen excerpts having been established as conveying sadness (see Peretz et al., 1998). Happy excerpts were written in a major mode at a fast tempo (average tempo = 136 beats per minute, range = 110 – 154 beats per minute), while sad excerpts were written in a minor mode at an average slow tempo of 52.3 beats per minute with a range of forty to sixty-nine beats per minute. Furthermore, each musical excerpt was repeated to create one-minute stimuli in such a manner that the beat was maintained, and then all musical excerpts were computer-generated with a piano timbre through use of a synthesizer (Rolland Sound Canvas SC50).

Khalfa et al. (2008) had participants sit comfortably in a silent room that contained a glass window dividing the silent room and the experimenter room, thus allowing the experimenter to view participants during the experimental procedure. After equipping participants with electrodes and apparatus for physiological measurements, three sample stimuli were presented to participants before beginning the experiment for the purpose of reducing the orienting response evoked by the first few trials, and to confirm that participants had comprehended how to use the verbal rating scales. Participants were then asked to relax for five minutes before beginning the actual experiment. Participants were also instructed to concentrate on the musical excerpts, asked not to move or speak, and to try to experience the emotions evoked by the musical excerpts as intensely as possible. Furthermore, participants were asked to verbally judge if each musical excerpt was happy or sad and to rate the valence (0-unpleasant to 9-pleasant) and arousal (0-relaxing to 9-stimulating) by responding to rating scales and a microphone that was placed in front of them. After listening to and asking to judge the mood of music that was designated as either “happy” or “sad”, Khalfa et al. (2008) analyzed whether fast and slow rhythm and/or tempo alone were significant enough to induce different types of effects on physiological measures such as HR and SCR. Results indicated that a) happy music induced more SCRs than sad music, fast rhythm, and fast tempo, b) the number of SCRs distinguished happy from sad music, but not fast from slow rhythm, nor fast from slow tempo, and c) HR was highest for participants at the forty-five second mark, compared to the fifteen and thirty second mark.

What can be learned from analyzing how music previously rated on valence and arousal affects individuals' ANS activity? Roy, Mailhot, Gosselin, Paquette, and Peretz (2009) recruited sixteen participants (seven males, nine females, mean age 25.1$\pm$9.3 years) aged twenty to forty years of age to examine how pleasant and unpleasant musical excerpts influence a wide variety of measures, including SCL and HR. Musical excerpts consisted of three 100 second pleasant and three 100 second unpleasant excerpts, which were chosen from a list of thirty musical excerpts. Each of the thirty possible excerpts were previously rated by twenty independent participants on valence and arousal scales (e.g., 0 – 9), with 0 and 9 representing pleasant and unpleasant for valence and relaxing and stimulating for arousal. Additionally, due to every unpleasant excerpt being labeled as arousing, each chosen excerpt was selected in a high range of arousal. Though pleasant and unpleasant excerpts did not differ in terms of arousal, pleasant excerpts were judged as being more pleasant than unpleasant excerpts. Furthermore, selected pleasant excerpts (i.e., *Opening of William Tell* by Rossini) consisted of classical or jazz/pop music which the authors described as "uplifting", and had relatively fast tempos, whereas selected unpleasant excerpts consisted of contemporary pieces of music. Lastly, all selected excerpts were normalized to average loudness across excerpts by setting the peak of each excerpt to 8% of the maximum volume allowed, which was done by utilizing the normalization option of the *Cool Edit 2* sound editing software.

Roy et al. (2009) carried out their experiments by having participants sit comfortably in a quiet room while listening to each pleasant and unpleasant musical excerpt (excerpts were counterbalanced across participants) while having their SCL and HR recorded. More specifically, when presenting participants with musical excerpts, each excerpt began with a 21.3 second induction phase and was followed by a startle probe that occurred at some point within an eleven second window, which was followed by a 2.3 second time window during which no startle probe could occur. This process was repeated until each 100 second musical excerpt concluded, with six eleven second time windows – separated by 2.3 second time windows – during which point a startle probe would occur. Concerning SCL and HR recordings, the only significant finding was that participant SCL was larger during pleasant as opposed to unpleasant musical excerpts.

Is it possible predict emotional valence experienced by the act of listening music from psychoacoustic features and physiological variables? Coutinho and Cangelosi's (2011) study's hypothesis was that emotional valence that people experience when they listen to music can be predicted from psychoacoustic features that include loudness, pitch level, pitch contour, tempo, texture, and sharpness, and that the accuracy of emotional valence can be improved when physiological variables such as SCR and HR are taken into account. Participants consisted of thirty-nine volunteers (twenty males, nineteen females) between twenty and fifty-three years of age (mean age 34±8 years). Leads were attached to participants' chest and left hand (for right handers; left hand otherwise) index and middle fingers respectively for measuring HR and SC. Physiological measures were collected through use of the WaveRider biofeedback system (Mind-Peak), with signals obtained with a sample rate of 128 Hz. Furthermore, participants reported their emotional state by using the EMuJoy software.

Utilizing an IAPS framework Coutinho and Cangelosi (2011) presented participants with nine pieces of classical music with a break of seventy-five seconds between each piece; pieces included *Romance No. 2* by Beethoven, *Partita No. 2* by Bach, and *Divertimento* by Mozart, among others. Results indicated that arousal was positively correlated with loudness, tempo, pitch level, and sharpness, while HR was also positively correlated with arousal. Additionally, HR was found to be positively correlated with loudness. Furthermore, linear discriminant analysis revealed that sharpness, pitch level, loudness, texture, and tempo significantly were significantly classified by mean arousal and valence values of the emotional quadrants of the IAPS, though loudness and texture showed negative standardized coefficients. Lastly, SCR and HR were also significantly classified in condition two of discriminant function analysis when added to the previously mentioned six psychoacoustic features, though SCR also showed a negative standardized coefficient. In summary, the inclusion of SCR and HR to the six previously mentioned psychoacoustic features improved the emotional classification of the experiment's music segments.

How do music genres defined by culture and psychoacoustic features influence ANS activity? Van der Zwaag et al.'s (2011) study differs from previously mentioned studies in that it compared various elements of music with various physiological measures for pop and rock music. Such elements of music included tempo (fast and slow), mode (major and minor), and percussiveness (high and low); specific pop songs used included *Heaven Help* by Lenny Kravitz, *Hotel California* by The Eagles, and *Crazy* by Seal, whereas specific rock songs used included *Imaginary* by Evanescence, *Satisfaction* by The Rolling Stones, and *James Dean* by The Eagles, with each song's tempo, mode, and percussiveness being labeled fast or slow, major or minor, and high or low, respectively (it would seem that the authors categorized songs they used according to musical characteristics as opposed to how people label or how bands label themselves). Participants consisted of thirty-two employees (sixteen men, mean age 26.3±4.03 years; sixteen women, mean age 24.6±2.22 years) at Philips Research, The Netherlands, who were told to complete a hand written computer task while listening to either music while van der Zwaag et al. recorded physiological measures such as SCR and HR.

The experimental procedure consisted of two blocks, one in which music stimuli were presented to the participants continuously and one in which each music excerpt was alternated with a period of silence: the continuous – or loop – block and the discontinuous – or break – block, respectively. Additionally, the order of each music stimulus within each music block was counterbalanced among participants by using a multiple eight-by-eight diagram-balanced Latin square design. Furthermore, each block started and ended with 2.5 minutes of silence, during which time the questionnaire on the emotional state was presented. Within each block participants answered the questionnaire after 120 seconds of each stimulus presentation, with a five-minute break between two blocks during which time the experimenter had a short conversation with the participants.

MANOVA analysis revealed that both participants' SCL and their amount of SCRs were higher during high-percussive music than low-percussive music. MANOVA analysis also revealed an interaction effect between tempo and percussiveness for the amount of participants' SCRs, as during fast tempo music participants exhibited more SCRs during high-percussive than low-percussive music. Additionally, fast tempo high-percussive music induced more SCRs in participants in comparison to slow tempo high-percussive music. Lastly, ANOVA analysis showed a main effect for tempo on heart rate variability (HRV).

How do music and non-musical sound affect ANS activity caused by stress tests? Thoma et al. (2013) examined how music influences the human stress response by both having volunteers listen to either relaxing music (*Miserere* by Allegri) (RM) or the sound of rippling water (SW), and having volunteers rest without acoustic stimulation (R) before performing the Trier Social Stress Test (TSST). Participants were recruited through use of an advertisement at the University of Zurich and the Swiss Federal Institute of Technology, Zurich, and chosen through a telephone screening in which participants had to meet criteria of being female, having a BMI between 18-25 kg/m^2, being twenty to thirty years of age, having Swiss or German as their native language, and having a regular menstrual cycle. Regarding the experimental procedure, participants were attached to the LifeShift electrophysiological measurement device.

After an adjustment period of thirty minutes, participants gave a basal saliva sample. Next, participants were brought to the TSST room twenty minutes prior to taking the TSST, where the experimenter introduced them to the procedure of the TSST. Participants were then brought to the intervention room and were seated in a comfortable chair before undergoing their assigned condition (RM, SW, or R). Participants gave a second saliva sample immediately after this part of the experiment, and then were escorted to the TSST room to complete the TSST. Furthermore, participants gave many additional saliva samples following the TSST with a fifteen-minute time period between each sample. In conclusion., while Thoma et al. assessed for many different variables (e.g., electrophysiological, biochemical, psychometric measurements), relevant findings were that participants in the sound of rippling water condition had faster recovery in terms of ANS activity compared to participants in the relaxing music and rest without acoustic stimulation conditions.

This subsection's previously discussed studies investigated how music influenced both HR and SCR. All discussed findings proved to be consistent. Heart rate was found to a) significantly enhance emotional experience induced from viewing affective images (Baumgartner et al., 2006); b) increase in the presence of high tempo music and decrease in the presence of low tempo music (Yamamoto et al., 2007); c) decrease during the experience of viewing pictures, as well as during the experience of listening to pleasant music (Sokhadze, 2007); d) increase during the experience of listening to sad music (Sokhadze, 2007); and e) improve emotional classification of music segments when paired with psychoacoustic variables (Coutinho & Cangelosi, 2011).

Skin conductance response was found to a) significantly enhance emotional experience induced from viewing affective images (Baumgartner et al., 2006); b) decrease during the experience of listening to happy music compared to negative emotional music (Baumgartner et al., 2006); c) have a positive correlation with fast tempo music (Gomez & Danuser, 2007); d) increase during the experience of viewing pictures (Sokhadze, 2007); e) increase during the experience of listening to happy music compared to sad music, fast rhythm music, and fast tempo music (Khalfa et al., 2008); f) distinguish music type but not rhythm or tempo; g) exhibit greater increases during the experience of listening to pleasant music compared to unpleasant music (Khalfa et al., 2008); h) improve emotional classification of music segments when paired with psychoacoustic variables (Coutinho & Cangelosi, 2011); i) exhibit greater increases for high-percussive music than low-percussive music (Van der Zwaag et al., 2011); and j) exhibit greater increases for fast tempo high-percussive music than for slow tempo high-percussive music (Van der Zwaag et al., 2011).

Chapter 3

Thesis Experiment

Thesis Objectives

The primary aim of the current thesis was to determine how psychophysiological measures of arousal (galvanic skin response, heart rate change) are altered by reactions to images while listening to different music genres. As noted by several researchers (Carpentier & Potter, 2007; Yamamoto et al., 2007; Chan et al., 2009; Dousty et al., 2011; Tsai et al., 2015), some genres of music have a relaxing effect. While the previously mentioned studies revealed that some genres of music can induce a relaxing effect as indexed by a reduction of autonomic arousal, these studies focused on how separate characteristics of music can induce relaxation. With this in mind, the current thesis investigated whether multiple genres of music differentially influenced autonomic arousal induced by high and moderate arousal stimuli in the form of negative valence (aversive) images, positive valence (pleasurable) images, and neutral images.

Hypotheses

Based on the findings of studies discussed in the previous literature review and the nature of music used in this study, the following hypotheses were predicted:

H1: The three music genres would elicit different levels of arousal regardless of picture type due to each genre's unique attributes. Due to the overall high-percussive, high-tempo, and erratic rhythm characteristics of songs used by Animals as Leaders, the MMM group was expected to elicit a strong ANS activation pattern. In contrast, due to the low-percussive, low-tempo, harmonic progressive, and repetitious rhythm characteristics of the AEM group, as well as the lack of percussion and presence of harmonic progressions in the CM group, both AEM and CM groups were expected to elicit lower ANS activation (Tsai et al., 2015).

H2: The high arousal images would elicit stronger ANS activation than Low-Moderate Arousal images.

H3: The negative valence images would elicit stronger ANS activation than positive valence images.

H4: An interaction between arousal, valence, and music genre would reveal that high arousal low valence images would not only elicit the strongest ANS activation, but this arousal would be most robust for the MMM condition.

Methods and materials

Participants

Data were collected from fifty Eastern Kentucky University undergraduate and graduate students (twenty-eight females, twenty-two males). An additional three participants (two females, one male) were not included in data analysis due to unusable physiological data. Participants were recruited in Eastern Kentucky University's Cammack building through flyers and professors offering extra credit for classes, as well as SONA system points. Consent was obtained before the start of the thesis experiment.

Stimuli

Pictures from the International Affective Picture System (IAPS) were used to induce ANS arousal (Lang, Bradley, & Cuthbert, 1997). The IAPS normative ratings were used to select a total of 138 pictures, 90 of high-arousal (45 negative valence and 45 positive valence), and 45 of moderate arousal and neutral valence. The pre-experimental phase included three IAPS pictures of low to moderate arousal ratings (arousal rating between 2.71 and 4.08) and neutral valence ratings (valence rating between 4.14 and 4.93), with each picture being displayed until participants' phasic ANS activity returned to baseline. The experimental phase included 135 IAPS pictures with 45 pictures of low to moderate arousal neutral valence ratings, 45 pictures of high-arousal negative valence ratings, and 45 pictures of high-arousal positive valence ratings that were presented in a random and counterbalanced sequence as determined by E-Prime software code. For experimental phase IAPS arousal and valence ratings, see Table 3. Each picture was displayed until participants' phasic ANS activity recovered to baseline. For details about IAPS pictures chosen for the current thesis project, see Tables 2 and 3 for both individual and mean IAPS ratings, respectively.

Music included songs and arrangements by musical artists Bach, Corelli, Mahler, Satie, Tycho, and Animals as Leaders. Bach, Corelli, Mahler, and Satie constituted the Classical Music (CM) experimental group, Tycho constituted the Ambient Electronic Music (AEM) experimental group, and Animals as Leaders constituted the Melodic Metal Group (MMM) experimental group.

Participants viewed color photographs while listening to three different music conditions. Each music condition had a different genre of music (AEM, CM, MMM). The genres differed in several attributes, including percussion, tempo, rhythm, and repetition. The experiment sought to identify how each genre differed in these attributes overall. Different types of images were shown to participants while they listened to music. The picture viewing task included 138 images that were 17.02 (vertical) by 22.86 (horizontal) centimeters in size.

Because different participants took different amounts of time to finish the experiment, each category of music had five to six different orders of song presentation that played in repeat (five for AEM and MMM, six for CM). Specifically, each music category had one song order presentation decided at random, with additional song order presentations used by changing the first song to the final song. Song order presentations for the AEM condition were twenty-three minutes and thirty-eight seconds, song order presentations for the CM condition were twenty-one minutes and thirty-four seconds, and song order presentations for the MMM condition were twenty-two minutes and forty-three seconds, with each song order presentation playing in repeat if participants took extended amounts of time to complete the experiment. For a list of all song order presentations, see Table 4. Furthermore, to view characteristics of each of the selected pieces of music, see Table 5. The average participant finished the picture viewing task within twenty to twenty-five minutes with a range of fifteen to fifty minutes.

Questionnaires

Participants filled out a biographical questionnaire and life events checklist prior to partaking in the thesis experiment. A music enjoyment scale was administered after participants had complete the thesis experiment.

Biographical Questionnaire – Participants provided information that included their age, education grade level, sex, gender, sexual orientation, medication prescriptions, and whether they had consumed any mind-altering substances, tobacco, or caffeine within the previous three hours (see Appendix A).

Life Events Checklist (LEC-5) – It was determined that potentially traumatic life experiences could cause participants to respond aversively to certain IAPS images. All participants filled out this instrument to determine whether or not they should be excluded from participating in this thesis experiment. The LEC-5 consists of 16 items that assess an individual's exposure to events known to potentially result in Post-Traumatic Stress Disorder (PTSD) or distress and includes one additional item assessing any other especially stressful event not included in the first 16 items (PTSD: National Center for PTSD, 2009). Furthermore, an additional question that asked participants if they had any phobias was added to the LEC-5 (Appendix B).

Music Enjoyment Scale – After the experiment's conclusion, participants were asked to complete a questionnaire that asked how much they enjoyed listening to each of the three genres of music. This instrument was created by the main experimenter and asked participants to rate the extent to which they enjoyed listening to each genre of music on a scale from 1 to 10 (Appendix C).

Procedure

Participants were scheduled for testing and were asked to not consume caffeine or alcohol within three hours before signing up for their scheduled session. At the psychophysiology lab, participants read and signed a consent form that also requested they not disclose details of the thesis experiment to others until the completion of the thesis experiment.

Participants were randomly assigned to one of six order conditions as determined by E-Prime software code that assigned one of six experimental conditions to each participant according to random assignment. All participants listened to the same music, the only difference between participants was the order presentation of songs. Each condition played each music genre's set of songs in a different order (e.g., AEM/CM/MMM, AEM/MMM/CM, CM/AEM/MMM, CM/MMM/AEM, MMM/AEM/CM, MMM/CM/AEM). In addition, each music genre's song order was also determined by E-Prime software code that assigned one of five to six song order presentations (five possible song order presentations for AEM and MMM, six possible song order presentations for CM).

Participants were informed ahead of time by means of experimental descriptions described through Eastern Kentucky University's SONA system that it was preferable for them to not consume caffeine within three hours prior to partaking in the proposed thesis experiment, though this was not a requirement. Furthermore, participants were asked to disclose information concerning any prescription medication they take that may influence ANS activity, as well as any history of psychiatric, psychological, or neurological disorders. Participants were assured that all information they disclosed would remain confidential and that records of such information would be destroyed at the completion of the experiment.

Once participants finished filling out forms they were to escorted to the psychophysiology lab's computer and fitted with equipment that included Ag/AgCl cup electrodes secured with isotonic electrode gel that assessed measures of their HR and SCR and headphones that were provided by the main experimenter. Participants were then informed that they were going to listen to music for one minute prior to starting the pre-experimental phase of the experiment. This was done so that participants' psychophysiological measures had time to habituate to the experiment's stimuli and thus prevent data analysis from being skewed.

Once participants completed the pre-experiment phase of viewing three IAPS images, the computer screen informed them that the experimental phase was about to begin. The three IAPS images used in the pre-experimental phase were not included in the experimental phase of the experiment.

The experiment was facilitated by the primary experimenter who oversaw each participant carry out this task in an adjacent room. The primary experimenter transitioned each IAPS image once participants' ANS activity had recovered to its baseline level. ANS activity typically returned to baseline after ten to fifteen seconds, though some participants' ANS activity took more than thirty seconds to return to baseline for individual images. If ANS activity was minimal, the primary experimenter waited five seconds before transitioning to the next image. Furthermore, participants listened to music throughout the entirety of both phases of the experiment. Once participants' ANS activity recovered to baseline after viewing the final IAPS image, the computer screen displayed a message that thanked participants for their time and instructed them to wait to be disconnected from the psychophysiological equipment.

Apparatus for Psychophysiological Data

Heart rate and skin conductance responses were recorded, digitized, and analyzed using Biopac software (BIOPAC Systems, Inc.). Due to miscommunication, twenty-five of forty-nine participants who had their heart rate coded had their heart rate data transformed with a finite impulse response (FIR) digital filter that included a) a low frequency cutoff of 0.48 Hertz per second, b) a high frequency ceiling of 2.50 Hertz per second, c) a coefficients limit of 117, and d) a Hamming window. This data transformation had a minimal effect on data analysis, and participants whose heart rate data were analyzed with filters will be re-analyzed without such filters when this thesis experiment is submitted for publication.

The stimulus computer was connected to the physiological recording system to enable the digitizer to reference stimulus onset. Two Ag/AgCL cup electrodes were secured to two adjacent fingers of participants' non-dominant hand with the use of an isotonic electrode gel (0.5% saline neutral base). Participants listened to music with Audio-Technica ATH-M50x Professional Monitor Headphones, which were chosen and provided by the main experimenter for features that included sound isolation, durability and comfort, long range (1.2m -3.0 straight cable cord), and quality of song performance (Audio-Technica, 2018). Skin conductance responses for each trial (i.e., each image presentation) were determined by subtracting the phasic skin electrodermal activity from tonic skin electrodermal activity.

Results

In order to examine the interplay between two independent variables, data were analyzed using repeated-measures analysis of variances (ANOVAs) with Music Type (AEM, CM, MMM) and Picture Type (high-arousal negative valence, high-arousal positive valence, neutral) serving as within-group variables. This analysis approach was used for each dependent variable (i.e., heart minimum and maximum heart rate and skin conductance response. Heart rate was measured in beats per minute, and skin conductance was measured in microohms/div.

For skin conductance response (SCR), main effects of Music Type and Picture Type were found, $F(2, 98) = 5.006$, $p < .009$, $\eta^2 = .093$, $F(2, 98) = 10.902$, $p < .00006$, η^2

= .182, respectively. For Music Type, contrasts revealed that SCR for melodic metal music (MMM) (M = 0.931) was greater than SCR for classical music (CM) (M = 0.828), $p < .002$. For Picture Type, contrasts revealed that a) SCR for high-arousal positive valence (HAPV) images (M = 0.97) was greater than SCR for high-arousal negative valence (HANV) images (M = 0.809), $p < .026$; b) SCR for HAPV images was greater than SCR for neutral images (M = 0.698), $p < .00004$; and c) SCR for HANV images was greater than SCR for neutral images, $p < .014$. See Figure 1 and Tables 6 and 10 for these findings.

For heart rate minimum (HR Min), main effects of Picture Type and a Music Type X Picture Type Interaction effect were found, $F(2, 96) = 4.756$, $p < .011$, $\eta^2 = .090$, $F(4, 192) = 3.133$, $p < .016$, $\eta^2 = .061$, respectively. For Picture Type, contrasts revealed that a) HR Min for high-arousal positive valence (HAPV) images (M = 77.678) was greater than HR Min for high-arousal negative valence (HANV) images (M = 72.685), $p < .021$; and b) HR Min for neutral images (M = 73.148) was greater than HR Min for HANV images (M = 72.685), $p < .004$. For the Music Type X Picture Type Interaction effect, contrasts revealed that a) the difference in HR Min between Ambient Electronic Music (AEM) (M = 72.738) and Melodic Metal Music (MMM) (M = 73.835) was significantly different than the difference in HR Min between HANV (M = 72.685) and HAPV images (M = 77.678), $p < .006$; b) the difference in HR Min between AEM (M = 72.738) and MMM (M = 73.835) was significantly different than the difference in HR Min between HANV (M = 72.685) images and neutral images (M = 73.148), $p < .014$; and c) the difference in HR Min between Classical Music (CM) (M = 73.010) and MMM (M = 73.835) was significantly different than the difference in HR Min between HANV

(M = 72.685) and HAPV images (M = 77.678), $p < .014$. See Figure 2 and Tables 8 and 10 for these findings.

For heart rate maximum (HR Max), trends were seen with Picture Type, $F(2, 96) = 2.300$, $p < .106$, $\eta^2 = .046$; and a Music Type X Picture Type Interaction, $F(4, 192) = 2.272$, $p < .063$, $\eta^2 = .045$. For the Music Type X Picture Type Interaction effect, contrasts revealed trends that showed that a) the difference in HR Max between CM (M = 85.568) and MMM (M = 86.783) was significantly different than the difference in HR Max between HANV images (M = 84.988) and neutral images (M = 86.392), $p < .053$; b) the difference in HR Max between CM (M = 85.568) and MMM (M = 86.783) was significantly different than the difference in HR Max between HANV images (M = 84.988) and HAPV images (M = 85.500), $p < .066$; c) the difference in HR Max between AEM (M = 85.297) and CM (M = 85.568) was significantly different than the difference in HR Max between neutral (M = 86.392) and HAPV images (M = 85.500), $p < .068$; and d) the difference in HR Max between AEM (M = 85.297) and CM (M = 85.568) was significantly different than the difference in HR Max between HANV (M = 84.988) and HAPV images (M = 85.500), $p < .078$. However, these trends were not statistically significant. See Figure 3 and Tables 8 and 10 for these findings. Furthermore, analyses that tested for order effects and differences in preference for each genre of music were not significant.

Chapter 4

Conclusion

Discussion

The current study examined whether different genres of music significantly influenced measures of ANS activity in different ways as measured by heart rate (HR) and skin conductance response (SCR). As hypothesized, MMM elicited higher levels of arousal compared to AEM and CM for both HR and SCR (Table 8), and high-arousal images elicited stronger ANS activation than Negative-Neutral (neutral) arousal images. Other hypotheses that negative valence (aversive) images would elicit stronger ANS activation than positive valence (pleasurable) images and that music genre would affect participants differently in relation to picture arousal and picture valence were not supported.

Expected results of supported hypotheses were partially supported. MMM elicited stronger ANS activation than AEM and CM as indexed by mean skin conductance response (SCR) and stronger ANS activation than CM as indexed by peak SCR, but AEM elicited higher peak SCR responses than MMM (see Table 9). These findings can be explained by elements of MMM that have been shown to predictably increase SCR (i.e., percussion, rhythm, tempo, lack of repetition) (Gomez & Danuser, 2007; Khalfa et al., 2008; Tsai et al., 2015; van der Zwaag et al., 2011).

Predicted results regarding differences in ANS activation by image valence (negative valence VS positive valence) were not supported but were revealed to be inversely accurate, as positive valence images elicited greater ANS activation than negative valence images across measures of SCR and HR (see Table 10). Additionally, ANS activation was found to be most profound for the MMM condition for both heart rate and skin conductance response, though heart rate was most profound for negative valence images, while skin conductance response was most profound for positive valence images. This could be explained by positive valence (pleasurable) images having a more profound influence on ANS activity than negative valence (aversive) images due to the act of listening to music being more pleasurable than aversive. Lastly, ANS activation for pre-experimental IAPS slides was not recorded, and frequency analysis of HR and SCR were beyond the scope of this thesis experiment.

Given this thesis experiment's findings, two generalizations can be affirmed. First, melodic metal music (MMM) induced greater ANS activation than both ambient electronic music (AEM) and classical music (CM), as indexed by heart rate (HR) and skin conductance response (SCR). MMM used in this thesis experiment had multiple distinct differences in musical elements in comparison to AEM and CM used in this thesis experiment, which could have accounted these findings. These differences include, a) presence, intensity, and frequency of percussion, b) unusual time signatures, c) erratic rhythms, d) lack of repetition, and e) accelerated tempo.

Previous research has analyzed the previously mentioned musical elements. Specifically, repetitious rhythms have been found to reduce SCRs (Tsai et al., 2015), high percussion frequency has been found to be positively correlated with SCR (van der Zwaag et al., 2011), low tempo has been found to reduce HR (Yamamoto et al., 2007), tempo has been found to be positively correlated with both SCR and HR (Coutinho &

Cangelosi, 2011; Gomez & Danuser, 2007; van der Zwaag et al., 2011), and tempo has been found to differentially influence SCR both individually and in conjunction with music genre (rock music and classical music) in combined interaction effects (Carpentier & Potter, 2007). Considering all of this, MMM's high frequency of percussion, erratic rhythms, lack of repetition, and fast tempo are possible explanations for the MMM condition displaying the highest levels of SCR and HR.

Second, positive valence images were found to elicit greater ANS activation than negative valence images as indexed by SCR and HR, and this effect was found to be most profound for MMM. These findings of stimuli valence having differential effects on ANS activity are supported by previous research. Specifically, decreases and increases in HR have been found to be induced by pleasant and sad music, respectively (Sokhadze, 2007), emotion has been correlated with SCR (Baumgartner et al., 2006; Khalfa et al., 2008), increased SCRs have been found to correlated with pleasant music compared to unpleasant music (Roy et al., 2009), decreased SCRs have been found to be correlated with happy music compared to negative emotional music (Baumgartner et al., 2006), music genre (arousal and sedative music) has been found to differentially stimulate the heart (Dousty et al., 2011), and mean arousal and valence values of the emotional quadrants of the IAPS have been found to classify tempo (Coutinho & Cangelosi, 2011). Though valence and emotion are two separate constructs, positive and negative valence can be equated to happy and sad or pleasant and unpleasant (Gomez & Danuser, 2007). Because close to all human beings derive pleasure from listening to music (Zatorre, 2015), positive valence images eliciting higher levels of ANS activation than negative valence and neutral images could be due to such ANS activation (heart rate and skin conductance response) being partially caused by participants' enjoying listening to music.

Limitations and Future Research

The current study has some limitations. Habituation effects were not considered during the execution of this study. Participants were asked to sit in front of a computer screen while listening to music and viewing images for twenty to sixty minutes, depending on how long it took participants' physiological readings to return to baseline. Consequently, boredom and absent-mindedness may have been factors that influenced this study's statistical findings. Additionally, stimuli presentation may have been lacking in ecological validity. While participants listened to music through noise-canceling headphones, experiences such as listening to music at live concerts is more likely to elicit ANS reactions that were analyzed in this study. Picture efficiency may also have been lacking in ecological validity. Viewing pictures for less than thirty seconds does not replicate ANS reactions brought about from first-hand experience, especially when habituation effects are considered. Furthermore, music and picture presentation were subject to order effects. The E-Prime program used for this study was coded to randomly assign participants' music order and randomly generate participants' picture presentation order. This was accomplished, but both music order and picture presentation order were unbalanced. Specifically, music order presentation frequency was not equal (see Table 12), and picture presentation often displayed consecutive high-arousal images five to ten times before displaying a neutral image, which may have caused ceiling effects. Lastly, baseline recovery of ANS arousal was not analyzed.

Designing experiments with high degrees of immersion and ecological validity can be challenging. Nevertheless, future research should strive to create experimental designs that accomplish these tasks, and do so diligence. Habituation and order effects could be further attenuated by creating code that presents stimuli with adherence to random assignment assignment while maintaining balanced or equal administration of experimental variables. Lastly, a more accurate understanding of how music influences ANS activity could possibly be achieved by designing experiments that contain both music groups and a non-music group.

Previous research has utilized psychoacoustic and functional neuroimaging methods both separately and simultaneously to identify correlations that include but are not limited to, ANS arousal and psychoacoustic features (Coutinho & Cangelosi, 2011), emotion and psychoacoustic features (Coutinho & Dibben, 2013), localization of function and psychoacoustic features (Hsieh, Fillmore, Rong, Hickok, & Saberi, 2012), localization of function and linguistic and musical syntax (Kunert, Willems, Casasanto, Patel, & Hagoort, 2005; Patel, 2003), emotion and music listening as indicated by emotional arousal and reported pleasurable states (Salimpoor, Benovoy, Longo, Cooperstock, & Zatorre (2009), and music and brain circuitry involved in pleasure and reward (Blood & Zatorre, 2001). Because this study revealed that different genres of music differentially influence ANS arousal, future research should utilize functional neuroimaging techniques to investigate specifically which psychoacoustic features of music differentially influence ANS arousal. Furthermore, due to the syntactic and psychoacoustic features of song lyrics and the human voice, designing experiments that make use of music that contains song lyrics is also worth investigating. Lastly, if future experiments identify which specific elements of music are able to influence ANS activity and can do so in a predictable manner, then music therapy may one day gain scientific credibility for being utilized in conjunction with current theories (Levine, 1997) and clinical treatments (Shapiro, 1989) used in the treatment of anxiety and trauma disorders.

Conclusion

The present study investigated whether different genres of music differentially influenced autonomic activity caused by looking at standardized images. The use of high arousal positive valence stimuli, high arousal negative valence stimuli, and moderate arousal moderate valence (neutral) stimuli were intended allow participants' physiological recordings to return to baseline and thus prevent ceiling effects. The present study was the first of its kind to analyze how three separate genres of music influenced autonomic arousal as measured by heart rate and skin conductance response. The unanticipated results of positive valence images inducing greater ANS activation than negative valence and neutral images warrants further study to more accurately determine specific elements of music that influence ANS activation. These results may support the notion that elements of music influence ANS activation in predictable ways regardless of preference in musical genre.

References

Ashley, E. A., & Niebauer, J. (2004). *Cardiology explained*. London: Remedica.

Baumgartner, T., Esslen, M., & Jäncke, L. (2006). From emotion perception to emotion experience: Emotions evoked by pictures and classical music. *International Journal of Psychophysiology*, *60*(1), 34-43. doi:10.1016/j.ijpsycho.2005.04.007

Bernston, G., Quigley, K., Lozano, D. (2000). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson. (3rd Ed.). Handbook of psychophysiology (Chapter 8). Cambridge, UK: Cambridge University Press.

Blood, A. J., & Zatorre, R. J. (2001). Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proceedings of the National Academy of Sciences of the United States of America, 98*(20), 11818-11823.

Burns, J., Labbé, E, Arke, B., Capeless, K., Cooksey, B., Steadman, A., & Gonzales, C. (2002). The effects of different types of music on perceived and physiological measures of stress. *Journal of Music Therapy, 39*(2), 101-116.

Carpentier, F. D., & Potter, R. F. (2007). Effects of music on physiological arousal: explorations into tempo and genre. *Media Psychology, 10*(3), 339-363. doi:10.1080/1521326070153304

Chan, M. F., Chan, E. A., Mok, E., & Tse, F. Y. (2009). Effect of music on depression levels and physiological responses in community-based older adults. *International Journal of Mental Health Nursing, 18*(4), 285-294. doi: 10.1111/j.1447-0349.2009.00614.x

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

Coutinho, E., & Dibben, N. (2013). Psychoacoustic cues to emotion in speech prosody and music. *Cognition & Emotion, 27*(4), 658-684. doi:10.1080/02699931.2012.732559

Dousty, M., Daneshvar, S., & Haghjoo, M. (2011). *Journal of Electrocardiology*, *44*(3), 396.e1-6. doi:10.1016/j.jelectrocard.2011.01.005

Ellis, R.J., & Thayer, J.F. (2010). Music and autonomic nervous system (dys)function. *Music Perception: An Interdisciplinary Journal 27*(4). 317-326. doi: 10.1525/MP.2010.27.4.317

Gomez, P., & Danuser, B. (2004). Affective and physiological responses to environmental noises and music. *International Journal of Psychophysiology, 53*(2), 91-103. doi: 10.1016/j.ijpsycho.2004.02.002

Gomez, P., & Danuser, B. (2007). Relationships between musical structure and psychophysiological measures of emotion. *Emotion, 7*(2), 377-387. doi:10.1037/1528-3542.7.2.377

Hilz, M. J., Stadler, P., Gryc, T., Nath, J., Habib-Romstoeck, L., Stemper, B., . . . Koehn, J. (2014). Music induces different cardiac autonomic arousal effects in young and older persons. *Autonomic Neuroscience*, *183*, 83-93. doi: 10.1016/j.autneu.2014.02.004

Hsieh, I., Fillmore, P., Rong, F., Hickok, G., & Saberi, K. (2012). FM-selective networks in human auditory cortex revealed using fMRI and multivariate pattern classification. *Journal of Cognitive Neuroscience, 24*(9), 1896-1907. doi:10.1162/jocn_a_00254

Khalfa, S., Roy, M., Rainville, P., Dalla Bella, S., & Peretz, I. (2008). Role of tempo entrainment in psychophysiological differentiation of happy and sad music?. *International Journal of Psychophysiology*, *68*(1), 17-26. doi:10.1016/j.ijpsycho.2007.12.001

Kunert, R., Willems, R. M., Casasanto, D., Patel, A. D., & Hagoort, P. (2015). Music and language syntax interact in Broca's Area: An fMRI study. *Plos ONE, 10*(10), 1-16. doi:10.1371/journal.pone.0141069

Lang, PJ, Bradley, MM and Cuthbert, BN (1997). International affective picture system (IAPS): Technical manual and affective ratings. *NIMH Center for the Study of Emotion and Attention*, 39–58

Lee, K.-R, Kim, J.-E., Yi, I., & Sohn, J.-H. (1997). A comparative study of emotions using the International Affective Picture System. *Proceedings 1997 Conference of Korean Society for Emotion and Sensibility, Seoul, November, 29*, 220–223 (In Korean, English summary).

Leeds, J. (2010). The power of sound: How to be healthy and productive using music and sound (Updated 2nd ed.). Rochester, Vermont: Healing Arts Press.

Levine, P. A. (1997). *Waking the Tiger: Healing Trauma*. Berkeley, California: North Atlantic Books.

Levitin, D. (2006). This is your brain on music: The science of a human obsession. New York, N.Y.: Dutton.

Olsen, K. N., & Stevens, C. J. (2013). Psychophysiological response to acoustic intensity change in a musical chord. *Journal of Psychophysiology, 27(1),* 16-26. doi:10.1027/0269-8803/a000082

Patel, A. (2010). *Music, language, and the brain* (1st ed.). Oxford: Oxford University Press.

Patel, A. (2003). Language, music, syntax and the brain. *Nature Neuroscience, 6*(7), 674-681.

Peretz, I., Gagnon, L., & Bouchard, B. (1998). Music and emotion: Perceptual determinants, immediacy, and isolation after brain damage. *Cognition, 68*(2), 111-141. doi: 10.1016/s0010-0277(98)00043-2

PTSD: National Center for PTSD. (2009, December 16). Retrieved February 10, 2018, from https://www.ptsd.va.gov/professional/assessment/te-measures/life_events_checklist.asp

Professional Monitor Headphones | Audio-Technica. (n.d.). Retrieved February 10, 2018, from http://www.audio-technica.com/monitorheadphones/

Pruneti, C., Lento, R., Fante, C., Corrozzo, C., & Fontana, F. (2010). Autonomic arousal and differential diagnosis in clinical psychology and psychopathology. *Journal of Psychopathology, 16*, 43-52.

Roy, M., Mailhot, J., Gosselin, N., Paquette, S., & Peretz, I. (2009). Modulation of the startle reflex by pleasant and unpleasant music. *International Journal of Psychophysiology, 71*(1), 37-42. doi:10.1016/j.ijpsycho.2008.07.010

Salimpoor, V. N., Benovoy, M., Longo, G., Cooperstock, J. R., & Zatorre, R. J. (2009). The rewarding aspects of music listening are related to degree of emotional arousal. *Plos One, 4*(10), e7487. doi:10.1371/journal.pone.0007487

Salimpoor, V. N., & Zatorre, R. J. (2013). Neural interactions that give rise to musical pleasure. *Psychology of Aesthetics, Creativity, and the Arts, 7*(1), 62-75. doi:10.1037/a0031819

Sammler, D., Grigutsch, M., Fritz, T., & Koelsch, S. (2007). Music and emotion: Electrophysiological correlates of the processing of pleasant and unpleasant music. *Psychophysiology, 44*(2), 293-304.

Shapiro, F. (1989). Efficacy of the Eye Movement Desensitization procedure in the treatment of traumatic memories. *Journal of Traumatic Stress*, *2*(2), 199-223. doi:10.1002/jts.2490020207

Sokhadze, E. M. (2007). Effects of music on the recovery of autonomic and electrocortical activity after stress induced by aversive visual stimuli. *Applied Psychophysiology & Biofeedback, 32*(1), 31-50. doi: 10.1007/s10484-007-9033-y

Songsterr. (2016). [Sheet music (e.g., time signature/time signature changes, guitar, bass, and drum tabs) for various musical artists]. *Guitar, bass, and drum tabs with rhythm.* Retrieved from http://www.songsterr.com/

Stern, R. M., Ray, W. J., & Quigley, K. S. (2001). *Psychophysiological recording*. (2nd ed.) New York: Oxford University Press.

Thoma, M. V., la Marca, R., Brönnimann, R., Finkel, L., Ehlert, U., & Nater, U. M. (2013). The effect of music on the human stress response. *Plos ONE, 8*(8).

Tsai, C., Yang, C., Chen, C., Chen, I., & Liang, K. (2015). Relaxation and executive control processes in listeners: An exploratory study of music-induced transient suppression of skin conductance responses. *Empirical Studies of the Arts, 33*(2), 125-143. doi: 10.1177/027623741559707

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

Yamamoto, M., Naga, S., & Shimizu, J. (2007). Positive musical effects on two types of negative stressful conditions. *Psychology of Music, 35*(2), 249-275.

Yakov, Y. (2015). Mixed In Key (7^{th} ed.) [computer software]. Maryland: Rockville.

Appendices

Appendix A:

Tables

Table 1 Musical Terms and Definitions

Musical Term	Definition
Amplitude/Loudness/Volume	A psychological impression of sound strength.
Contour	The general shape of a melody when taking into account only the pattern of "up" and "down".
Frequency	How often any regularly repeated events occur in an assumed unit of time.
Pitch	How subjectively high or low a tone sounds to the ear.
Rhythm	Durations of a series of notes and how they group together as sounds.
Sound	A sensation caused by an object or objects that vibrate.
Tempo	The general speed or pace of a musical piece.
Timbre	The tone color or characteristic quality that distinguishes one voice or musical instrument from another as determined by the harmonics of sound.

Table 2 International Affective Picture System (IAPS) Slide Ratings and Categories

IAPS Slide Number	**Arousal/Valence Rating w/SD**	**Category/Type of Image**
#1022 (High Arousal, Negative-Neutral Valence)	6.02, 1.97/4.26, 2.04	Snake
#1033 (High Arousal, Negative-Neutral Valence)	6.13, 2.15/3.67, 1.94	Snake
#1040 (High Arousal, Negative-Neutral Valence)	6.25, 2.13/3.99, 2.24	Snake
#1050 (High Arousal, Negative-Neutral Valence)	6.87, 1.68/3.46, 2.15	Snake
#1052 (High Arousal, Negative-Neutral Valence)	6.52, 2.23/3.50, 1.87	Snake
#1120 (High Arousal, Negative-Neutral Valence)	6.93, 1.68/3.79, 1.93	Snake
#1200 (High Arousal, Negative-Neutral Valence)	6.03, 2.38/3.95, 2.22	Spider
#1201 (High Arousal, Negative-Neutral Valence)	6.36, 2.11/3.55, 1.88	Spider
#1300 (High Arousal, Negative-Neutral Valence)	6.79, 1.84/3.55, 1.78	Pit Bull
#1304 (High Arousal, Negative-Neutral Valence)	6.37, 1.93/3.37, 1.58	Attack Dog
#1321 (High Arousal, Negative-Neutral Valence)	6.64, 1.89/4.32, 1.87	Bear
#1525 (High Arousal, Negative-Neutral Valence)	6.51, 2.25/3.09, 1.72	Attack Dog
#1930 (High Arousal, Negative-Neutral Valence)	6.42, 2.07/3.79, 1.92	Shark
#1931 (High Arousal, Negative-Neutral Valence)	6.80, 2.02/4.00, 2.28	Shark
#2200 (Low-Moderate Arousal)	3.18, 2.17/4.79, 1.38	Neutral Face
#2210 (Low-Moderate Arousal)	**3.01, 1.76/4.70, 0.93**	**Neutral Face**
#2220 (Low-Moderate Arousal)	4.93, 1.65/5.03, 1.39	Male Face
#2310 (Low-Moderate Arousal)	4.16, 2.01/7.06, 1.52	Mother
#2311 (Low-Moderate Arousal)	4.42, 2.28/7.54, 1.37	Mother
#2312 (Low-Moderate Arousal)	4.02, 1.66/3.71, 1.64	Mother
#2352.2 (High Arousal, Negative-Neutral Valence)	6.25, 2.10/2.09, 1.50	Bloody Kiss
#2487 (Low-Moderate Arousal)	4.05, 1.92/5.20, 1.80	Musician
#2488 (Low-Moderate Arousal)	3.91, 1.87/5.73, 1.14	Musician
#2489 (Low-Moderate Arousal)	3.80, 1.93/5.66, 1.44	Musician
#2493 (Low-Moderate Arousal)	3.34, 2.10/4.82, 1.27	Neutral Male
#2500 (Low-Moderate Arousal)	3.61, 1.91/6.16, 1.54	Man
#2512 (Low-Moderate Arousal)	3.46, 1.75/4.86, 0.84	Man
#2513 (Low-Moderate Arousal)	3.29, 1.67/5.80, 1.29	Woman
#2514 (Low-Moderate Arousal)	3.50, 1.81/5.19, 1.09	Woman
#2516 (Low-Moderate Arousal)	3.50, 1.88/4.90, 1.43	Elderly Woman
#2683 (High Arousal, Negative-Neutral Valence)	6.21, 2.15/2.62, 1.78	War
#2811 (High Arousal, Negative-Neutral Valence)	6.90, 2.22/2.17, 1.38	Gun
#3400 (High Arousal, Negative-Neutral Valence)	6.91, 2.22/2.35, 1.90	Severed Hand
#3500 (High Arousal, Negative-Neutral Valence)	6.99, 2.19/2.21, 1.34	Attack
#3530 (High Arousal, Negative-Neutral Valence)	6.82, 2.09/1.80, 1.32	Attack
#3550.1 (High Arousal, Negative-Neutral Valence)	6.29, 1.96/2.35, 1.39	Plane Crash
#4604 (High Arousal, Neutral-Positive Valence)	6.09, 1.87/5.98, 1.76	Erotic Couple
#4608 (High Arousal, Neutral-Positive Valence)	6.47, 1.96/7.07, 1.66	Erotic Couple
#4647 (High Arousal, Neutral-Positive Valence)	6.21, 2.26/5.89, 1.95	Erotic Couple
#4651 (High Arousal, Neutral-Positive Valence)	6.34, 2.05/6.32, 2.18	Erotic Couple
#4658 (High Arousal, Neutral-Positive Valence)	6.47, 2.14/6.62, 1.89	Erotic Couple
#4659 (High Arousal, Neutral-Positive Valence)	6.93, 2.07/6.87, 1.99	Erotic Couple
#4660 (High Arousal, Neutral-Positive Valence)	6.58, 1.88/7.40, 1.36	Erotic Couple
#4664 (High Arousal, Neutral-Positive Valence)	6.72, 2.08/6.61, 2.23	Erotic Couple
#4668 (High Arousal, Neutral-Positive Valence)	7.13, 1.62/6.67, 1.69	Erotic Couple
#4669 (High Arousal, Neutral-Positive Valence)	6.11, 2.42/5.97, 2.13	Erotic Couple
#4670 (High Arousal, Neutral-Positive Valence)	6.74, 2.03/6.99, 1.73	Erotic Couple
#4693 (High Arousal, Neutral-Positive Valence)	6.57, 1.90/6.16, 1.91	Erotic Couple
#4694 (High Arousal, Neutral-Positive Valence)	6.42, 2.08/6.69, 1.70	Erotic Couple
#4695 (High Arousal, Neutral-Positive Valence)	6.61, 1.88/6.84, 1.53	Erotic Couple

Table 2 (continued)

IAPS Slide Number	Arousal/Valence Rating w/SD	Category/Type of Image
#4697 (High Arousal, Neutral-Positive Valence)	6.62, 1.69/6.22, 1.76	Erotic Couple
#4698 (High Arousal, Neutral-Positive Valence)	6.72, 1.72/6.50, 1.67	Erotic Couple
#4800 (High Arousal, Neutral-Positive Valence)	7.07, 1.78/6.44, 2.22	Erotic Couple
#4810 (High Arousal, Neutral-Positive Valence)	6.66, 2.14/6.56, 2.09	Erotic Couple
#5010 (Low-Moderate Arousal)	3.00, 2.25/7.14, 1.50	Flower
#5020 (Low-Moderate Arousal)	2.63, 2.10/6.32, 1.68	Flower
#5030 (Low-Moderate Arousal)	2.74, 2.13/6.51, 1.73	Flower
#5220 (Low-Moderate Arousal)	3.91, 2.27/7.01, 1.50	Nature
#5250 (Low-Moderate Arousal)	3.64, 2.27/6.08/2.01	Nature
#5510 (Low-Moderate Arousal)	2.82, 2.18/5.15, 1.43	Mushroom
#5520 (Low-Moderate Arousal)	2.95, 2.42/5.33, 1.49	Mushroom
#5530 (Low-Moderate Arousal)	2.87, 2.29/5.38, 1.60	Mushroom
#5593 (Low-Moderate Arousal)	3.98, 2.31/6.47, 1.57	Sky
#5594 (Low-Moderate Arousal)	4.15, 2.76/7.39, 1.45	Sky
#5621 (High Arousal, Neutral-Positive Valence)	6.99, 1.95/7.57, 1.42	Skydivers
#5626 (High Arousal, Neutral-Positive Valence)	6.10, 2.19/6.71, 2.06	Hang Glider
#5629 (High Arousal, Neutral-Positive Valence)	6.55, 2.11/7.03, 1.55	Hiker
#5711 (Low-Moderate Arousal)	3.03, 1.96/6.62, 1.65	Field
#5725 (Low-Moderate Arousal)	3.55, 2.32/7.09, 1.41	Field
#5750 (Low-Moderate Arousal)	3.14, 2.25/6.60, 1.84	Nature
#5764 (Low-Moderate Arousal)	3.55, 2.32/6.74, 1.64	Field
#5991 (Low-Moderate Arousal)	4.01, 2.44/6.55, 2.09	Sky
#6212 (High Arousal, Negative-Neutral Valence)	6.01, 2.44/2.19, 1.49	Soldier
#6230 (High Arousal, Negative-Neutral Valence)	7.35, 2.01/2.37, 1.57	Aimed Gun
#6312 (High Arousal, Negative-Neutral Valence)	6.37, 2.30/2.48, 1.52	Abduction
#6520 (High Arousal, Negative-Neutral Valence)	6.59, 2.08/1.94, 1.27	Attack
#6821 (High Arousal, Negative-Neutral Valence)	6.29, 2.02/2.38, 1.72	Gang
#6834 (High Arousal, Negative-Neutral Valence)	6.28, 1.90/2.91, 1.73	Police
#7031 (Low-Moderate Arousal)	2.03, 1.51/4.52, 1.11	Shoes
#7032 (Low-Moderate Arousal)	3.18, 1.88/4.82, 1.46	Shoes
#7033 (Low-Moderate Arousal)	3.99, 2.14/5.40, 1.57	Train
#7037 (Low-Moderate Arousal)	3.71, 2.08/4.81, 1.12	Trains
#7038 (Low-Moderate Arousal)	3.01, 1.96/4.82, 1.20	Shoes
#7039 (Low-Moderate Arousal)	3.29, 2.15/5.93, 1.58	Train
#7055 (Low-Moderate Arousal)	3.02, 1.83/4.90, 0.64	Lightbulb
#7170 (Low-Moderate Arousal)	3.21, 2.05/5.14, 1.28	Lightbulb
#7184 (Low-Moderate Arousal)	3.66, 1.89/4.84, 1.02	Abstract Art
#7185 (Low-Moderate Arousal)	2.64, 2.04/4.97, 0.87	Abstract Art
#7188 (Low-Moderate Arousal)	4.28, 2.16/5.50, 1.12	Abstract Art
#7236 (Low-Moderate Arousal)	3.79, 2.24/5.64, 1.31	Lightbulb
#7247 (Low-Moderate Arousal)	4.14, 2.23/5.05, 1.00	Abstract Art
#7248 (Low-Moderate Arousal)	4.22, 2.11/5.22, 1.07	Abstract Art
#7249 (Low-Moderate Arousal)	3.97, 2.08/5.24, 1.04	Abstract Art
#7640 (High Arousal, Neutral-Positive Valence)	6.03, 2.43/5.00, 1.31	Skyscraper
#7650 (High Arousal, Neutral-Positive Valence)	6.15, 2.24/6.62, 1.91	City
#8030 (High Arousal, Neutral-Positive Valence)	7.35, 2.02/7.33, 1.76	Skier
#8034 (High Arousal, Neutral-Positive Valence)	6.30, 2.16/7.06, 1.53	Skier
#8080 (High Arousal, Neutral-Positive Valence)	6.65, 2.20/7.73, 1.34	Sailing
#8158 (High Arousal, Neutral-Positive Valence)	6.49, 2.05/6.53, 1.34	Hiker
#8160 (High Arousal, Neutral-Positive Valence)	6.97, 1.62/5.07, 1.97	Rock Climber

Table 2 (continued)

IAPS Slide Number	Arousal/Valence Rating w/SD	Category/Type of Image
#8161 (High Arousal, Neutral-Positive Valence)	6.09, 2.24/6.71, 1.64	Hang Glider
#8163 (High Arousal, Neutral-Positive Valence)	6.53, 2.21/7.14, 1.61	Parachute
#8170 (High Arousal, Neutral-Positive Valence)	6.12, 2.30/7.63, 1.34	Sailboat
#8178 (High Arousal, Neutral-Positive Valence)	6.82, 2.33/6.50, 2.00	Cliff Diver
#8179 (High Arousal, Neutral-Positive Valence)	6.99, 2.35/6.48, 2.18	Bungee Jumper
#8180 (High Arousal, Neutral-Positive Valence)	6.59, 2.12/7.12, 1.88	Cliff Divers
#8185 (High Arousal, Neutral-Positive Valence)	7.27, 2.08/7.57, 1.52	Sky Divers
#8186 (High Arousal, Neutral-Positive Valence)	6.84, 2.01/7.01, 1.57	Sky Surfer
#8190 (High Arousal, Neutral-Positive Valence)	6.28, 2.57/8.10, 1.39	Skier
#8191 (High Arousal, Neutral-Positive Valence)	6.19, 2.17/6.07, 1.73	Ice Climber
#8200 (High Arousal, Neutral-Positive Valence)	6.35, 1.98/7.54, 1.37	Water Skier
#8206 (High Arousal, Neutral-Positive Valence)	6.41, 2.19/6.43, 1.75	Surfers
#8300 (High Arousal, Neutral-Positive Valence)	6.14, 2.21/7.02, 7.02	Pilot
#8341 (High Arousal, Neutral-Positive Valence)	6.40, 2.27/6.25, 1.86	Wing Walker
#8485 (High Arousal, Negative-Neutral Valence)	6.46, 2.10/2.73, 1.62	Fire
#8490 (High Arousal, Neutral-Positive Valence)	6.68, 1.97/7.20, 2.35	Roller Coaster
#8492 (High Arousal, Neutral-Positive Valence)	7.31, 1.64/7.21, 2.26	Roller Coaster
#8499 (High Arousal, Neutral-Positive Valence)	6.07, 2.31/7.63, 1.41	Roller Coaster
#9050 (High Arousal, Negative-Neutral Valence)	6.36, 1.97/2.43, 1.61	Plane Crash
#9163 (High Arousal, Negative-Neutral Valence)	6.53, 2.21/2.10, 1.36	Soldiers
#9250 (High Arousal, Negative-Neutral Valence)	6.60, 1.87/2.57, 1.39	War Victim
#9252 (High Arousal, Negative-Neutral Valence)	6.64, 2.23/1.98, 1.59	Dead Body
#9300 (High Arousal, Negative-Neutral Valence)	6.00, 2.41/2.26, 1.76	Dirty
#9321 (High Arousal, Negative-Neutral Valence)	6.24, 2.23/2.81, 2.14	Vomit
#9325 (High Arousal, Negative-Neutral Valence)	6.01, 2.54/1.89, 1.23	Vomit
#9405 (High Arousal, Negative-Neutral Valence)	6.08, 2.40/1.83, 1.17	Sliced Hand
#9410 (High Arousal, Negative-Neutral Valence)	7.07, 2.06/1.51, 1.15	Soldier
#9413 (High Arousal, Negative-Neutral Valence)	6.81, 2.09/1.76, 1.08	Hanging
#9414 (High Arousal, Negative-Neutral Valence)	6.49, 2.26/2.06, 1.48	Execution
#9620 (High Arousal, Negative-Neutral Valence)	6.11, 2.10/2.70, 1.64	Shipwreck
#9635.1 (High Arousal, Negative-Neutral Valence)	6.54, 2.27/1.90, 1.31	Man On Fire
#9902 (High Arousal, Negative-Neutral Valence)	6.00, 2.15/2.33, 1.38	Car Accident
#9904 (High Arousal, Negative-Neutral Valence)	6.08, 2.06/2.36, 1.35	Car Accident
#9910 (High Arousal, Negative-Neutral Valence)	6.20, 2.16/2.06, 1.26	Car Accident
#9940 (High Arousal, Negative-Neutral Valence)	7.15, 2.24/1.62, 1.20	Explosion
#7009 (Pre-Experimental Slide)	3.01, 1.97/4.93, 1.00	Mug
#7025 (Pre-Experimental Slide)	2.72, 2.20/4.63, 1.17	Stool
#7054 (Pre-Experimental Slide)	4.08, 2.13/4.14, 1.09	Glass

Note:
IAPS = International Affective Picture System

Table 3 IAPS Slide Rating Averages by Music Condition

MMM Conditions (n = 45)	AEM Conditions (n = 45)	CM Conditions (n = 45)
HANV = 6.43 (.36) (Arousal)	HANV = 6.45 (.29) (Arousal)	HANV = 6.46 (.39) (Arousal)
HANV = 2.80 (.80) (Valence)	HANV = 2.54 (.79) (Valence)	HANV = 2.75 (.83) (Valence)
HAPV = 6.57 (.40) (Arousal)	HAPV = 6.56 (.42) (Arousal)	HAPV = 6.56 (.42) (Arousal)
HAPV = 6.73/0.73 (Valence)	HAPV = 6.78 (.69) (Valence)	HAPV = 6.78 (.69) (Valence)
Lower A = 3.55 (.56) (Arousal)	Lower A = 3.46 (.56) (Arousal)	Lower A = 3.49 (.53) (Arousal)
Lower A = 5.87 (.91) (Valence)	Lower A = 5.44 (.99) (Valence)	Lower A = 5.66 (.79) (Valence)
All High A & V = 6.50 (.37) (Arousal)	All High A & V = 6.52 (.35) (Arousal)	All High A & V = 6.50 (.33) (Arousal)
All High A & V = 4.76 (.75) (Valence)	All High A & V = 4.66 (.74) (Valence)	All High A & V = 4.75 (.69) (Valence)
All Slides = 5.50 (.46) (Arousal)	All Slides = 5.51 (.40) (Arousal)	All Slides = 5.51 (.40) (Arousal)
All Slides = 5.05 (.84) (Arousal)	All Slides = 5.01 (.81) (Arousal)	All Slides = 5.04 (.71) (Arousal)

Note:
AEM = Ambient Electronic Music
CM = Classical Music
MMM = Melodic Metal Music
Standard Deviation in Parentheses

Melodic Metal Music Condition Slides = 1052, 1120, 1201, 1300, 1321, 6212, 6312, 6821, 6834, 8485, 9250, 9300, 9405, 9902, 9940 (Higher A Negative V); 4658, 4660, 4669, 4695, 4697, 4810, 5621, 7640, 8030, 8163, 8170, 8180, 8191, 8341, 8492 (Higher A Positive V); 2211, 2311, 2489, 2493, 2513, 5020, 5220, 5520, 5594, 5750, 7038, 7039, 7055, 7188, 7249 (Lower A)

Ambient Electronic Music Condition Slides = 1022, 1050, 1525, 1930, 2352, 2811, 3500, 6520, 9163, 9252, 9321, 9410, 9620, 9635.1, 9910 (Higher A Negative V); 4608, 4647, 4651, 4659, 4668, 4670, 7650, 8034, 8080, 8160, 8161, 8179, 8185, 8300, 8499 (Higher A Positive V); 2210, 2312, 2488, 2500, 2516, 5010, 5250, 5510, 5725, 5991, 7031, 7037, 7170, 7184, 7247 (Lower A)

Classical Music Slides = 1033, 1040, 1200, 1304, 1931, 2683, 3400, 3530, 3550.1, 6230, 9050, 9325, 9413, 9414, 9904 (Higher A Negative V); 4604, 4664, 4693, 4694, 4698, 4800, 5626, 5629, 8158, 8178, 8186, 8190, 8200, 8206, 8490 (Higher A Positive V); 2200, 2310, 2487, 2512, 2514, 5030, 5530, 5593, 5711, 5764, 7032, 7033, 7185, 7236, 7248 (Lower A)

Pre-Experimental Images Slides and Ratings = 7009, 7025, 7054 (A = 3.27/0.72, V = 4.57/0.40)

*A = Arousal
*V = Valence
*Music condition ratings consist of means/standard deviations
*Arousal was categorized as low (below 4.5) and high (above 5.0)

Table 4 Music Categories and Song Orders

Music Category	Song Order
Ambient Electronic Music	Awake/L/Coastal/Ascension/Apogee
Ambient Electronic Music	L/Coastal/Ascension/Apogee/Awake
Ambient Electronic Music	Coastal/Ascension/Apogee/Awake/L
Ambient Electronic Music	Ascension/Apogee/Awake/L/Coastal
Ambient Electronic Music	Apogee/Awake/L/Coastal/Ascension
Classical Music	Allegro/Gymnopédia No. 3/Fourth Symphony-Poco Adagio/Polonaise/Gymnopédia No. 1/ Adagio From Concerto Grosso Opus 6, No. 8
Classical Music	Gymnopédia No. 3/Fourth Symphony-Poco Adagio/Polonaise/Gymnopédia No. 1/ Adagio From Concerto Grosso Opus 6, No. 8/Allegro
Classical Music	Fourth Symphony-Poco Adagio/Polonaise/Gymnopédia No. 1/ Adagio From Concerto Grosso Opus 6, No. 8/Allegro/Gymnopédia No. 3
Classical Music	Polonaise/Gymnopédia No. 1/ Adagio From Concerto Grosso Opus 6, No. 8/Allegro/Gymnopédia No. 3/Fourth Symphony-Poco Adagio
Classical Music	Gymnopédia No. 1/ Adagio From Concerto Grosso Opus 6, No. 8/Allegro/Gymnopédia No. 3/Fourth Symphony-Poco Adagio/Polonaise
Classical Music	Adagio From Concerto Grosso Opus 6, No. 8/Allegro/Gymnopedia No. 3/Fourth Symphony-Poco Adagio/Polonaise/Gymnopedia No. 1
Melodic Metal Music	An Infinite Regression/Thoroughly At Home/Tooth And Claw/CAFO/Song of Solomon
Melodic Metal Music	Thoroughly At Home/Tooth And Claw/CAFO/Song of Solomon/An Infinite Regression
Melodic Metal Music	Tooth And Claw/CAFO/Song of Solomon/An Infinite Regression/Thoroughly At Home
Melodic Metal Music	CAFO/Song of Solomon/An Infinite Regression/Thoroughly At Home/Tooth And Claw
Melodic Metal Music	Song of Solomon/An Infinite Regression/Thoroughly At Home/Tooth And Claw/CAFO

Table 5 Song Characteristics

Song	Characteristics	Source
An Infinite Regression (Animals As Leaders)	120 BPM, Gb Minor, 3:25, 3/4 to 7/8 to 3/8 to 3/4 to (5/4 to 11/8 looped) to 7/16 to 3/4 to 6/4	http://www.songsterr.com/a/wsa/animals-as-leaders-an-infinite-regression-drum-tab-s93234t3, Mixed In Key (7th ed.)
CAFO (Animals As Leaders)	155 BPM, Gb Minor; 6:41, 8/4 to 9/4 to (4/4 to 5/4 looped) to 9/4 to 3/4 to 2/4	http://www.songsterr.com/a/wsa/animals-as-leaders-cafo-drum-tab-s64162t2, Mixed In Key (7th ed.)
Song of Solomon (Animals As Leaders)	170 BPM, E Minor, 4:14, (4/4 to 3/4 looped) to 4/4 to 15/16 to 7/8 to 4/4 to 3/8 to 4/4 to 6/4 to 4/4 to (5/4 to 4/4 looped) to 6/4 to (4/4 to 5/4 looped) to 4/4 to 6/4 to 2/4 to (4/4 to 3/4 looped) to 6/4 to 2/4 to 4/4 to (5/4 to 4/4 looped) to 6/4 to (4/4 to 5/4 looped) to 4/4 to 6/4 to 2/4 to 4/4 to (3/4 to 4/4 looped) to 3/4 to 2/4 to 4/4	http://www.songsterr.com/a/wsa/animals-as-leaders-song-of-solomon-tab-s65926t0, Mixed In Key (7th ed.)
Thoroughly at Home (Animals As Leaders)	145 BPM, Db Minor, 4:00, 5/8 to 4/4 to (7/4 to 4/4 looped) to (2/4 to 4/4 looped) to 9/8 to 4/4 to 6/4 to 5/4 to 6/4 to 4/4 to 6/4 to 5/4 to 6/4	http://www.songsterr.com/a/wsa/animals-as-leaders-thoroughly-at-home-tab-s65925t0, Mixed In Key (7th ed.)
Tooth and Claw (Animals As Leaders)	152 BPM, B Minor, 4:23, 4/4 to 5/4 to 4/4 to (6/4 to 4/4 looped) to (7/4 to 6/4 looped) to 4/4 to 6/4 to 4/4	http://www.songsterr.com/a/wsa/animals-as-leaders-tooth-and-claw-drum-tab-s397926t4, Mixed In Key (7th ed.)

Table 5 (continued)

Song	Characteristics	Source
Adagio From Concerto Grosso Opus 6, No. 8	124 BPM, D# Major, 3:03	Mixed In Key (7th ed.)
Allegro (J. S. Bach)	89 BPM, C Minor, 5:01	Mixed In Key (7th ed.)
Polonaise (J.S. Bach)	129 BPM, B Minor, 2:58	Mixed In Key (7th ed.)
Fourth Symphony, Poco Adagio	112 BPM, D Major, 4:22	Mixed In Key (7th ed.)
Gymnopédie 1 (Erik Satie)	130 BPM, D Major, 3:42	Mixed In Key (7th ed.)
Gymnopédie 3 (Erik Satie)	81 BPM, A Minor, 2:28	Mixed In Key (7th ed.)
Apogee (Tycho)	88 BPM, A# Minor, 4:20	Mixed In Key (7th ed.)
Ascension (Tycho)	85 BPM, D# Minor, 4:24	Mixed In Key (7th ed.)
Awake (Tycho)	88 BPM, F# Major, 4:43	Mixed In Key (7th ed.)
Coastal Break (Tycho)	120 BPM, F# Minor, 5:34	Mixed In Key (7th ed.)
L (Tycho)	114 BPM, G# Major, 4:37	Mixed In Key (7th ed.)

Note:
BPM = Beats Per Minute
# = Sharp, b = Flat
Characteristics = BPM (All), Song Duration (All), Key/Mode (All), Time Signature Changes (Animals as Leaders)
Duration of Songs = Animals as Leaders (22:43), Bach/Corelli/Mahler/Satie (21:34), Tycho (23:38)

Table 6 Mean Skin Conductance Response by Music Type and Picture Type

Music Type	Picture Type	Number of Participants	Skin Conductance Response Mean
AEM	HANV	50	.795 (.965)
AEM	Neutral	50	.700 (.857)
AEM	HAPV	50	.988 (1.053)
CM	HANV	50	.700 (.869)
CM	Neutral	50	.652 (.723)
CM	HAPV	50	.803 (.870)
MMM	HANV	50	.933 (1.084)
MMM	Neutral	50	.741 (.954)
MMM	HAPV	50	1.119 (1.092)

Note:
Standard Deviation in Parentheses
AEM = Ambient Electronic Music
CM = Classical Music
MMM = Melodic Metal Music
HANV= High-Arousal Negative Valence
HAPV = High-Arousal Positive Valence

Table 7 Mean Heart Rate Minimum and Maximum by Music Type and Picture Type

Music Type	Picture Type	Number of Participants	HR Minimum Mean	HR Maximum Mean
AEM	HANV	49	71.856 (14.703)	85.251 (14.403)
AEM	Neutral	49	73.151 (14.378)	86.298 (14.742)
AEM	HAPV	49	73.190 (13.930)	84.345 (13.917)
CM	HANV	49	72.263 (14.202)	84.857 (15.200)
CM	Neutral	49	73.059 (14/186)	85.928 (15.556)
CM	HAPV	49	73.666 (14.062)	85.871 (16.420)
MMM	HANV	49	73.938 (15.492)	87.113 (18.532)
MMM	Neutral	49	74.043 (14.866)	86.950 (18.241)
MMM	HAPV	49	73.560 (14.820)	86.284 (18.538)

Note:
Standard Deviation in Parentheses
AEM = Ambient Electronic Music
CM = Classical Music
MMM = Melodic Metal Music
HANV= High-Arousal Negative Valence
HAPV = High-Arousal Positive Valence

Table 8 Descriptive Statistics of Heart Rate and Skin Conductance Response by Music Type

Measure	AEM (All Pictures)	CM (All Pictures)	MMM (All Pictures)
HR-Min. 2-4 SPS Minimum (n = 49)	40.295	46.714	46.211
HR-Min. 2-4 SPS Maximum (n = 49)	114.514	119.185	116.874
HR-Min. 2-4 SPS Mean (n = 49)	72.738 (14.207)	73.010 (14.068)	73.835 (14.942)
HR-Max 4-7 SPS Minimum (n = 49)	62.074	65.350	64.384
HR-Max 4-7 SPS Maximum (n = 49)	121.644	141.528	172.135
HR-Max 4-7 SPS Mean (n = 49)	85.297 (14.059)	85.568 (15.443)	86.783 (18.323)
SCR Minimum (n = 50)	0.016	0.019	0.014
SCR Maximum (n = 50)	4.027	3.166	4.020
SCR Mean (n = 50)	0.828 (0.898)	0.719 (0.772)	0.931 (0.966)

Note:
SPS = Seconds Post Stimulus
Standard Deviation Parentheses

Table 9 Minimum, Peak, and Mean Skin Conductance Response by Music Type

Music Type	Number of Participants	SCR Minimum	SCR Peak	Mean
Ambient Electronic Music	50	.016	4.027	.828 (.898)
Classical Music	50	.018	3.166	.719 (.772)
Melodic Metal Music	50	.014	4.020	.931 (.966)

Note:
Standard Deviation in Parentheses

Table 10 Mean Heart Rate and Skin Conductance Response by Picture Type

Picture Type	Number of Participants	Mean
SCR High-Arousal Negative Valence	50	0.809 (0.973)
SCR Neutral	50	0.698 (0.845)
SCR High-Arousal Positive Valence	50	0.970 (1.005)
HR-Min. 2-4 SPS High-Arousal Negative Valence	49	72.685 (14.799)
HR-Min. 2-4 SPS Neutral	49	73.148 (14.477)
HR-Min. 2-4 SPS High-Arousal Positive Valence	49	77.678 (14.271)
HR-Max. 4-7 SPS High-Arousal Negative Valence	49	84.988 (16.045)
HR-Max. 4-7 SPS Neutral	49	86.392 (16.180)
HR-Max. 4-7 SPS High-Arousal Positive Valence	49	85.500 (16.291)

Note:
Standard Deviation in Parentheses
SPS = Seconds Post Stimulus

Table 11 Music Order Presentation Frequency

Music Order	Frequency	Percent	Cumulative Percent
AEM/CM/MMM	15	28.3	28.3
AEM/MMM/CM	8	15.1	43.4
CM/AEM/MMM	4	7.5	50.9
CM/MMM/AEM	10	18.9	69.8
MMM/AEM/CM	4	7.5	77.4
MMM/CM/AEM	12	22.6	100.0
Total	53	100.0	100.0

Appendix B:

Figures

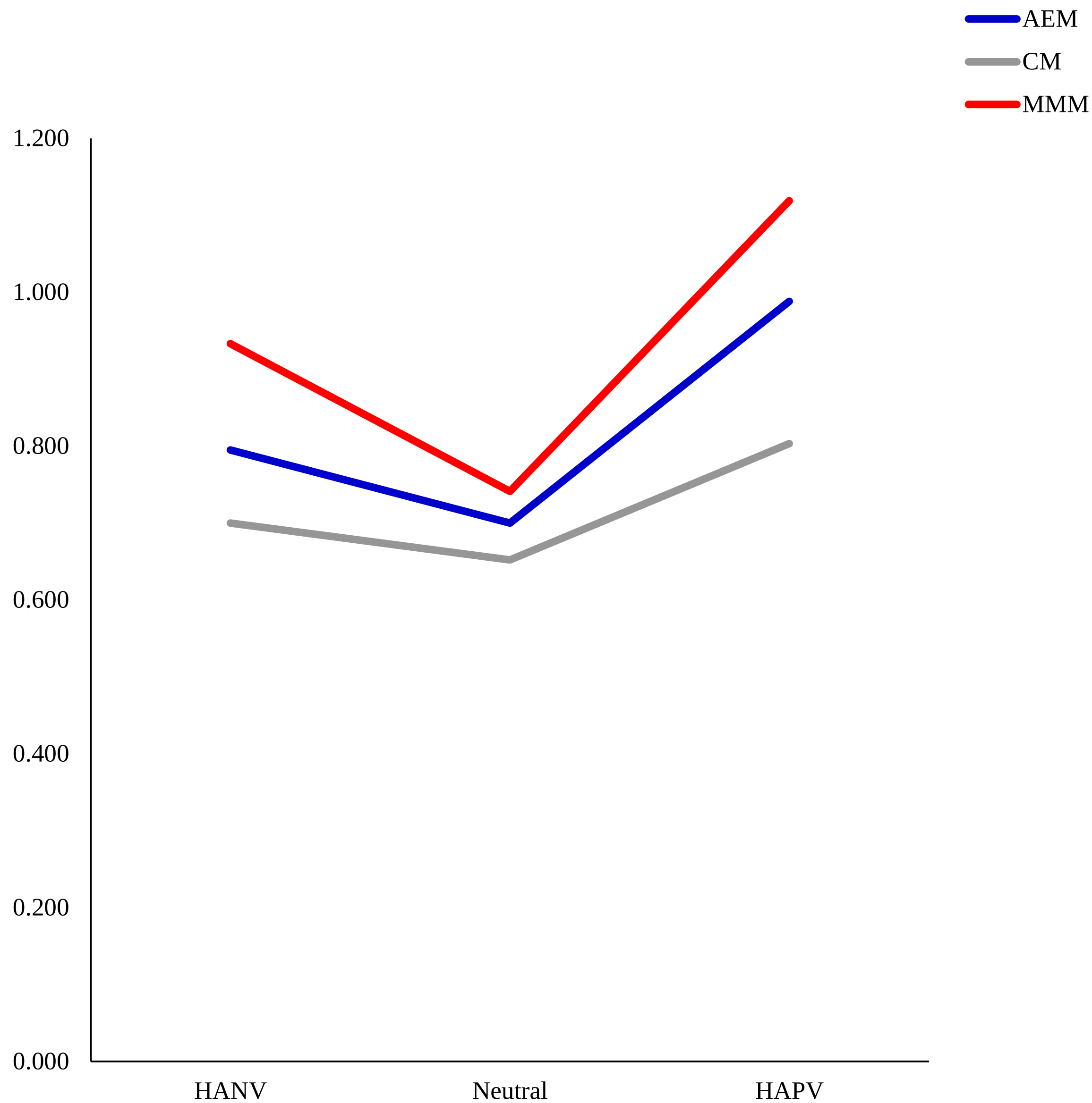

Figure 1 Music Type X Picture Type Interaction (Skin Conductance Response)

Note:
HANV = High-Arousal Negative Valence, HAPV = High-Arousal Positive Valence

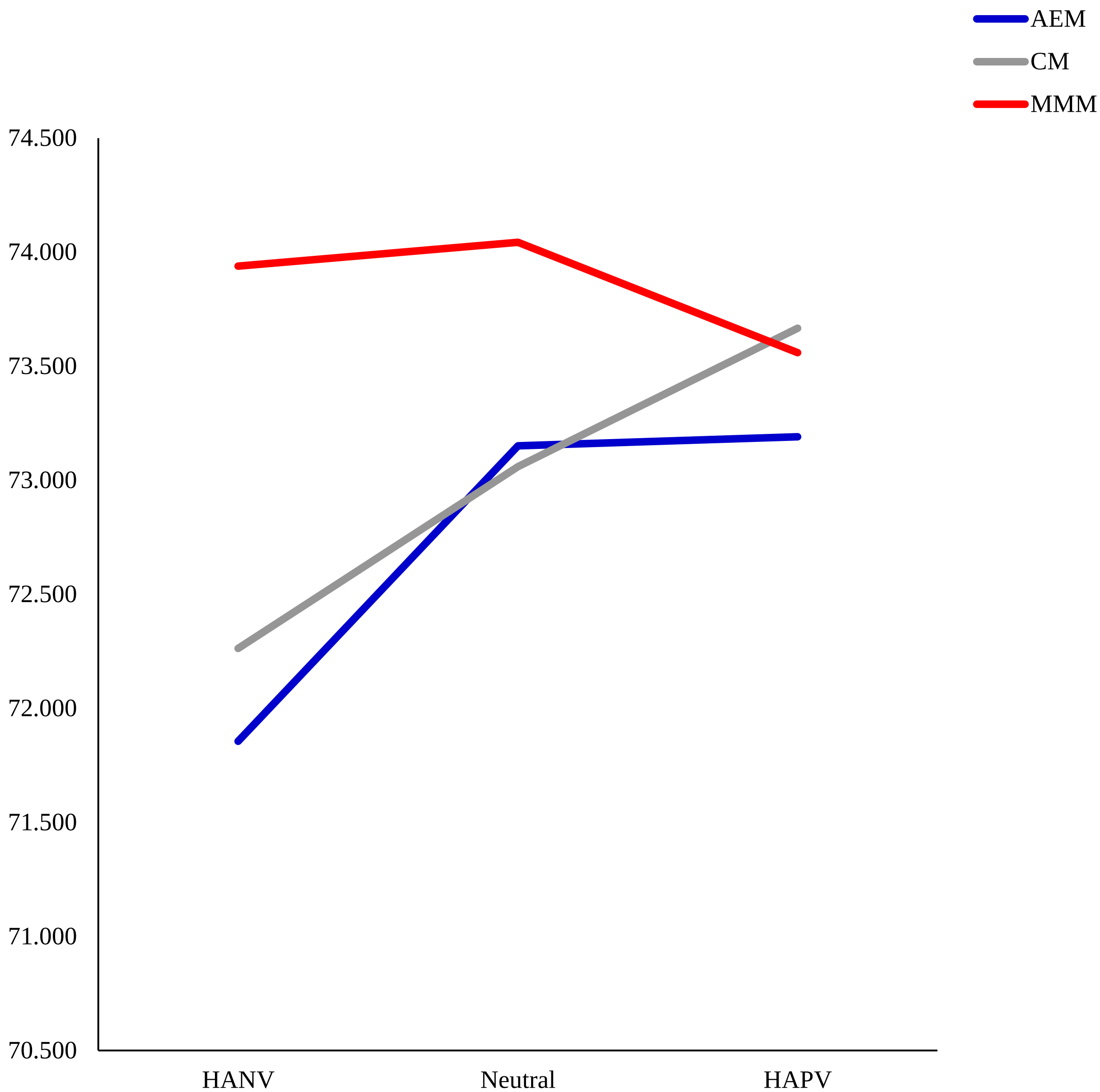

Figure 2 Music Type X Picture Type Interaction (Minimum Heart Rate)

Note:
HANV = High-Arousal Negative Valence, HAPV = High-Arousal Positive Valence

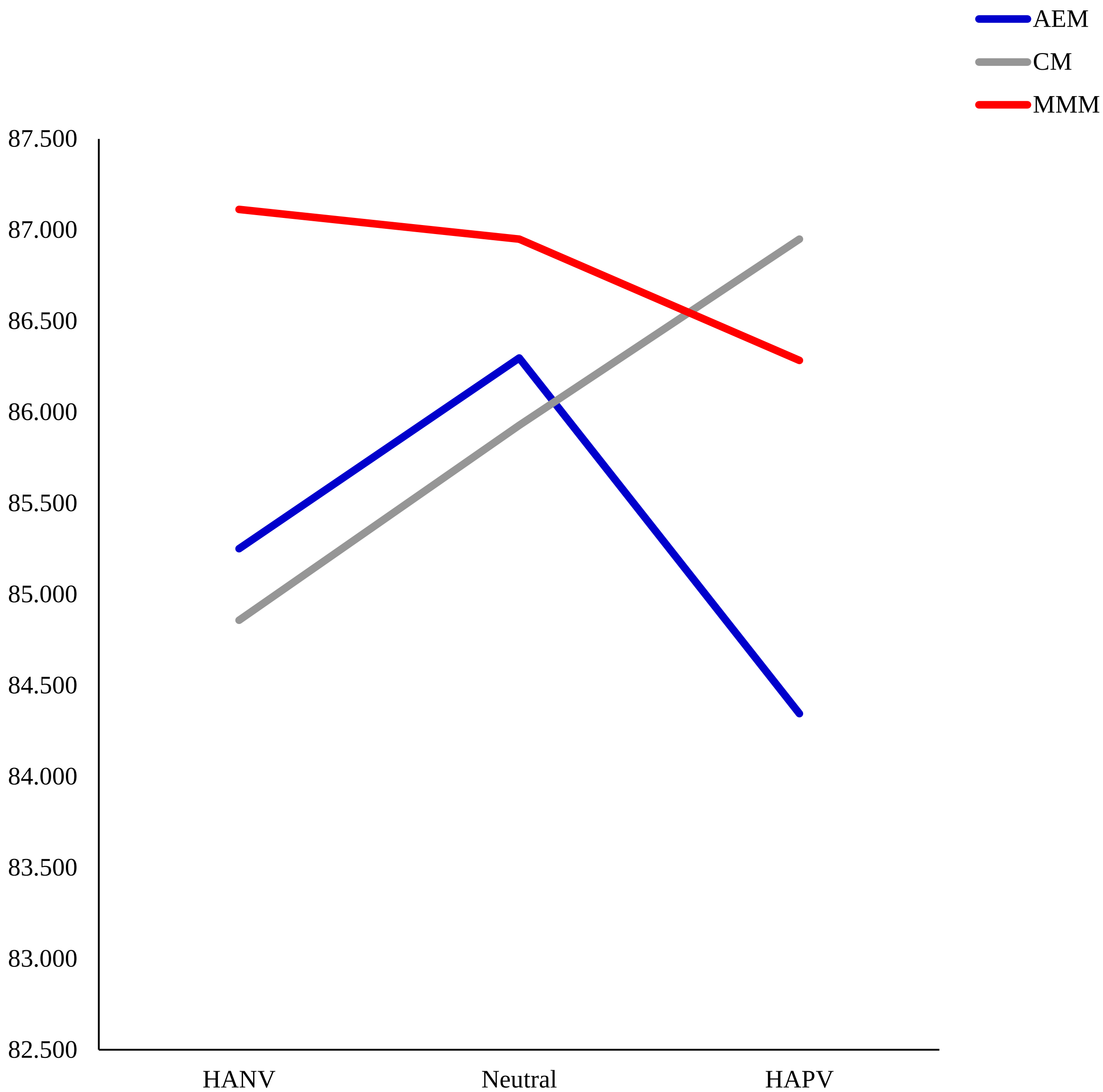

Figure 3 Music Type X Picture Type Interaction (Maximum Heart Rate)

Note:
HANV = High-Arousal Negative Valence, HAPV = High-Arousal Positive Valence

Appendix C:

Biographical Questionnaire

BIOGRAPHICAL QUESTIONNAIRE

Thesis Form 1 SONA ID: _______________ Date: _____________________

Biographical Questionnaire

All responses are *anonymous*.
Please print clearly and *do not write your name anywhere on this form*.

1. Age:

______ 18 – 20 years old
______ 21 – 30 years old
______ 31 – 40 years old
______ 41 years or older

2. Level of Education:

______ Undergraduate Freshman/Sophomore
______ Undergraduate Junior/Senior
______ Graduate Student
______ Other: _________________________

3. Sex:

______ Male
______ Female
______ Intersex
______ Transgender: MTF / FTM (Circle one)

4. Gender Identity:

Masculine Androgynous Feminine

1…………..…..……...…....2……….………….…..…...3……….…….….……..…...4…….……..…….……..5

5. Sexual Orientation:

Gay/Lesbian Bisexual Straight

1…………..…..……...…....2……….………….…..…...3……….…….….……..…...4…….……..…….……..5

Please circle YES or NO to the following questions:

BIOGRAPHICAL QUESTIONNAIRE (continued)

YES	**NO**	**7. Are you currently taking any medicine or drug(s) that affect your ability to think or learn?**
YES	**NO**	**8. Have you taken any mind-altering substance (legal or illegal) in the last week?**
YES	**NO**	**9. Do you regularly use tobacco products? (Once a week or more)**
YES	**NO**	**10. Did you consume any product containing caffeine today?**
YES	**NO**	**11. Including tobacco, caffeine, and any other stimulant, was the amount you consumed today normal for you?**

Appendix D:

Life Events Checklist

LIFE EVENTS CHECKLIST (LEC-5)

Event	***Happened to me***	***Witnessed it***	***Learned about it***	***Not Sure***	***Doesn't apply***
1. Natural disaster (for example, flood, hurricane, tornado, earthquake)					
2. Fire or explosion					
3. Transportation accident (for example, car accident, boat accident, train wreck, plane crash)					
4. Serious accident at work, home, or during recreational activity					
5. Exposure to toxic substance (for example, dangerous chemicals, radiation)					
6. Physical assault (for example, being attacked, hit, slapped, kicked, beaten up)					
7. Assault with a weapon (for example, being shot, stabbed, threatened with a knife, gun, bomb)					
8. Sexual assault (rape, attempted rape, made to perform any type of sexual act through force or threat of harm)					
9. Other unwanted or uncomfortable sexual experience					
10. Combat or exposure to a war-zone (in the military or as a civilian)					
11. Captivity (for example, being kidnapped, abducted, held hostage, prisoner of war)					
12. Life-threatening illness or injury					

Appendix D (continued)

13. Severe human suffering					
14. Sudden, violent death (for example, homicide, suicide)					
15. Sudden, unexpected death of someone close to you					
16. Serious injury, harm, or death you caused to someone else					
17. Any other very stressful event or experience					
18. Do you have any phobias					

Appendix E:

Music Enjoyment Scale

MUSIC ENJOYMENT SCALE

On a scale of 1 to 10, how much did you enjoy listening to each genre of music?

Ambient Electronic Music

1............2............3............4............5............6............7............8............9............10

Classical Music

1............2............3............4............5............6............7............8............9............10

Melodic Metal Music

1............2............3............4............5............6............7............8............9............10