



5-2015

Emotional Responses to Musical Dissonance in Musicians and Nonmusicians

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EMOTIONAL RESPONSES TO MUSICAL DISSONANCE IN
MUSICIANS AND NONMUSICIANS

by

Rebecca Joan Bumgarner

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Master's of Music
School of Music
Western Michigan University
May 2015

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EMOTIONAL RESPONSES TO MUSICAL DISSONANCE IN MUSICIANS AND NONMUSICIANS

Rebecca Joan Bumgarner

Western Michigan University, 2015

The purpose of this project was to investigate the influence of music education on individuals' subjective and physiological responses to consonant and dissonant excerpts. Participants were categorized as having high experience (HE) or low experience (LE) in music education. Participants listened to 40 randomized excerpts of music, half of which were consonant, the other half dissonant. Electrodermal Activity (EDA) and Facial Electromyography (EMG) data were collected for each participant, as well as self-reports of perceived pleasantness for each excerpt. It was expected that HE participants "learned" dissonance through music education, and therefore would respond more strongly to dissonant excerpts. As expected, dissonant excerpts received significantly more negatively-valenced subjective ratings than consonant excerpts across all subjects ($F(1,28)=58.4, p<.001$). HE participants did rate dissonant excerpts as more unpleasant than did LE participants, however, this difference was not significant ($F(1, 28)=1.47, p=.236$). This study supports that most individuals find dissonance to be more unpleasant than consonance. Further analysis of the physiological data acquired during these trials could potentially add to the body of research examining the impact music education has on physiological responses to dissonance and consonance.

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ACKNOWLEDGEMENTS

I would like to begin by acknowledging Delphine Dellacherie, et al. for carrying out the study upon which the current project is based. Reading this study created the basis for the current project, and answered many questions along the way.

Secondly, I would like to thank the members of my committee, Ed Roth, Brian Wilson, and Dr. Lisa Baker. I would like to extend extra appreciation to my committee chair, Ed Roth, whose encouragement and positive demeanor helped me keep going throughout this entire process.

Additionally I would like to thank Amanda Ziemba, for spending many hours in the BRAIN Lab with me experimenting with and figuring out the equipment, and Leah Brown for faithfully showing up to help facilitate these trials.

Finally I would like to thank my friends and family. My mother, Lynn Bumgarner (my Grammar Police), has proofread every major paper I have ever written, and I am so incredibly grateful to her for that, along with her unwavering support. My husband, Jeffery Utter, came to my aid whenever my computer simply refused to format my paper correctly. The support of my friends and family has been a driving force for me to keep going, even when the going got tough.

Rebecca Joan Bumgarner

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“An unstable tone combination is a dissonance; its tension demands an onward motion to a stable chord. Thus dissonant chords are “active”; traditionally they have been considered harsh and have expressed pain, grief, and conflict”. —*Roger Kamien*

CHAPTER I

INTRODUCTION

Statement of the Problem

From infancy, there appears to be an innate preference in humans, cross-culturally, for consonant music over dissonant music (Trainor & Heinmiller, 1998; Zentner, 1998; Masataka, 2006). This preference seems to carry into adulthood, regardless of exposure to various genres of music, which has been indicated both through self-report (Peretz, 2001; Dellacherie, Hugueville, Peretz, & Samson, 2010) and physiological measures (Baumgartner, Esslen, & Jancke, 2006; Roy, Mailhot, Gosselin, Paquette, & Peretz, 2008; Nater, Abbruzzese, Krebs, & Ehlert, 2006; Steinbeis, Koelsch, & Sloboda, 2006; Dellacherie et al., 2010). In several studies utilizing physiological measures to delineate a preference for consonance over dissonance, it was inferred that increased electrodermal activity (EDA) and increased corrugator (eyebrow) muscle activity were thought to indicate negatively-valenced emotions, and that increased zygomatic (smile) muscle activation was thought to indicate positively-valenced emotions (Sammler, Grigutsch, Fritz, & Koelsch, 2007; Baumgartner, Esslen, & Jancke, 2006; Roy, et al., 2008; Dellacherie et al., 2010). Along with research substantiating this preference for consonance over dissonance, there is recent literature suggesting that this

preference is more pronounced in individuals with musical training than those without (Brattico, Pallesen, Varyagina, Baily, Anourova, et al., 2008; Pallesen et al., 2005; Dellacherie et al., 2010). The present study sought to address the effect of musical training on subjective ratings and physiological responses to consonant and dissonant excerpts of music, and to examine the inherent impact music education has on how individuals respond to musical dissonance.

Research Questions

The reasoning supporting humans' preference for consonance over dissonance has been the subject of a long-standing debate. Although several studies have been executed utilizing self-report measures identifying dissonant music as more unpleasant than consonant music, only a limited number of studies utilizing the physiological measures of electrodermal activity and facial electromyography were found (Baumgartner, Esslen, & Jancke, 2006; Roy, et. al, 2008; Nater et al., 2006; Steinbeis, Koelsch, & Sloboda, 2006; Dellacherie et al., 2010). The current study anticipated adding to this body of research by asking the following research questions:

R_{1a}: Will dissonant excerpts produce more negatively-valenced subjective ratings than consonant excerpts?

R_{1b}: Will subjective ratings of dissonant and consonant excerpts differ between musicians and nonmusicians?

R₂: Will dissonant excerpts increase electrodermal activity to a greater degree than consonant excerpts?

R₃: Will dissonant excerpts increase corrugator muscle activation to a greater degree than consonant excerpts?

R₄: Will consonant excerpts increase zygomatic muscle activation to a greater degree than dissonant excerpts?

R₅: Will physiological responses differ between musicians and nonmusicians?

Definition of Terms

The corrugator muscle region (corrugator supercilii) is located over the brow, and is activated when frowning. It is reportedly associated with the subjective experience of displeasure (Cacciopo et al., 2000).

Electrodermal Activity (EDA) is defined as an increase in the electrical conductivity of the skin, increased sweat gland activity, increased blood flow, and increased skin temperature (Dawson, Schell, & Courtney, 2011). An increase in EDA is associated with arousal and displeasure (Cacioppo et al., 2000).

Electromyography (EMG) is a test used to measure electrical activity of muscles, both when at rest and when activated (Truven Health Analytics Inc., 2012). The current study utilized facial EMG to determine activity in the corrugator and zygomatic regions.

The zygomatic muscle region (zygomaticus major) is located in the cheek and is activated when smiling. It is reportedly associated with the subjective experience of pleasure (Cacioppo et al., 2000) but can also be activated by grimacing or ironic smiling (Ansfield, 2007).

Summary

Although the debate about consonance and dissonance dates back two and a half millennia, there is a lack of substantial valid research on the topic. The current study intended to add to this growing field of research by examining musicians' and nonmusicians' subjective and physiological reactions to both dissonant and consonant excerpts of music. To examine these reactions, a previous study's methods (Dellacherie et al., 2010) were utilized to increase validity. It was expected that the dissonant excerpts would be rated as more negatively-valenced than the consonant excerpts, and that these ratings would be more extreme within the musician participants. It was expected that both electrodermal activity and corrugator muscle activity would be increased during dissonant excerpts, and that these responses would be more pronounced in musicians. It was expected that zygomatic muscle activity would be increased during consonant excerpts, and that this response would be more pronounced in musicians. Musicians were expected to react more strongly to the excerpts of music, given their experience and expertise.

CHAPTER II

REVIEW OF LITERATURE

On Dissonance

Over 2500 years ago Pythagoras proposed the first known recorded guidelines pertaining to consonance and dissonance. He proposed that simpler ratios of tone combination (*e.g.*, unison, octave, perfect fifth) were aesthetically pleasing, and therefore “consonant.” Their frequency ratios were made up of smaller whole numbers than their more complex, “dissonant” counterparts (*e.g.*, major/minor second, major/minor seventh, tritone). The Pythagorean rule—that music progresses with consonant intervals and resolves dissonant intervals—became the basis for Western music (Foss, Altschuler, & James, 2007). This theory was revisited when Helmholtz further explained dissonance in *On the Sensations of Tone* (1877). He noted that when the frequencies of two pitches are close together, an unpleasant “beating” sensation or “roughness” is experienced. He declared that the dissonance of a chord depends on its perceived roughness. This psychoacoustic theory of dissonance has been researched and expanded for over a century (Plomp & Levelt, 1965; Bodner, Gilboa, & Amir, 2007; LoPresto, 2009; Makowski & Epstein, 2012; Johnson-Laird, Kang, & Leong, 2012).

According to the psychoacoustic theory of dissonance, the roughness of dissonance is a sensory experience in which the physical vibrations of sound are received by the auditory system and converted into nerve impulses (Johnson-Laird, Kang, & Leong, 2012). While the frequencies of a consonant interval can be resolved by neurons of the auditory system, most frequencies of a dissonant interval are too close together to be resolved. These unresolved frequencies interfere with each other, resulting in the

perception of roughness that is indicative of dissonance (Tramo, Cariani, Delgutte & Braida, 2001). This perception of roughness (or lack thereof in the case of consonance) creates the basis of subjective reactions to dissonance (Johnson-Laird, Kang, & Leong, 2012).

Not everyone experiences dissonance with the same intensity, hence one of the reasons for this study. Makowski and Epstein (2012) suggest that musicians, when learning music, are essentially “practicing dissonance.” Multiple studies suggest that musicians are more aware of dissonance, and therefore may react more strongly to its presence, both subjectively and physiologically (Bigand, Parncutt & Lerdahl, 1996; Bigand & Parncutt, 1999; Schon, Regnault, Ystad, & Besson, 2005; Steinbeis, Koelsch & Sloboda, 2004; Minati et al., 2009; Dawson, 2011).

Infants' Reactions to Dissonance

Although research indicates that reactions to dissonance may be increased with musical instruction (Pallesen et al., 2005; Schon et al., 2005; Dellacherie et al., 2010), preference for consonance does not appear to be a learned phenomenon. Several studies have indicated that babies are born with an innate preference for consonance over dissonance, despite prenatal auditory stimuli (Trainor & Heinmiller, 1998; Zentner, 1998; Trainor, Tsang & Cheung, 2002; Masataka, 2006).

Trainor and Heinmiller (1998) tested six-month old infants for their preference for consonance or dissonance using a head-turn test. The auditory stimuli consisted of intervals. For consonance, octaves and perfect fifths were used; for dissonance, tri-tones and augmented octaves were used. Twenty trials were performed, and 11 of the 12

infants spent more time looking at the consonance-producing visual. In the same study, a second experiment was performed on 16 six-month old infants. In that experiment, the auditory stimuli consisted of both the Mozart Minuet in C Major, and the same minuet altered with dissonant intervals. The tempo and dynamic level remained the same. Again the study indicated the infants' preference for consonance over dissonance.

In a similar study, Zentner (1998) utilized two 35-second melodies as the independent variables, with the same tempo, rhythm, and dynamic level. These two stimuli were presented to 24 undergraduate students, and 23/24 showed a preference for the consonant version, over the dissonant version. Additionally, 32 four-month-old infants were tested using the head-turn test. The infants were observed under four separate trials. During these trials each infant sat in a room with both a research assistant and parent behind them. A speaker sat in their visual field to their right, and was covered with an attractive black and white pattern. The stimuli were delivered through this speaker, and infant reactions were recorded. The infants remained fixated on the consonant stimulus for a significantly longer time, and more showed fretful behavior during the dissonant stimulus. This study also suggested that infants have an innate bias toward consonance over dissonance.

Similar results were obtained in a 2002 study, in which two- and four-month old infants were exposed to the same series of consonant and dissonant intervals as used in Trainor and Heinmiller's 1998 study. Due to the undeveloped motor skills of two-month old infants, this study measured how long each infant fixated on the sound source, rather than utilizing a head-turn test. As in prior studies, both the two- and four-month old

infants fixated on the consonant stimulus for a longer time than its dissonant counterpart (Trainor, Tsang, & Cheung, 2002).

A more recent study was performed in a similar manner with a slightly different category of test subjects. Whereas the prior studies had tested infants of hearing parents in a Western culture, the new study, by Masataka (2006), tested the newborns of non-hearing parents in Japan. These parents lived in a deaf community, making extensive prenatal exposure to music, or even much speech, highly unlikely. The experiment was conducted with 27 two-day-old newborns of deaf parents, and 15 two-day old newborns of hearing parents—all in Japan. The auditory stimuli were the same as those used in the Trainor and Heinmiller (1998) experiment—the Mozart Minuet and an altered dissonant version of it. In this experiment, both groups of infants looked longer at the consonant versus the dissonant stimulus. This study suggested that infants' preference for consonance over dissonance was not necessarily specific to any prenatal experience, but may have been innate.

These studies all suggested that the infants fixated on the consonant stimulus longer due to an innate preference. However there is a possibility the infants, especially the older ones, had previous experience with music. In this case the longer fixation times could have been due to familiarity. Even in the cases where familiarity was unlikely, the prolonged fixation could have been the result of increased arousal or interest, which would not necessarily equate to a preference. However the infants did, regardless of age, culture, or exposure, fixate on the consonant stimulus for a longer period of time in all of the aforementioned studies.

Subjective Responses to Dissonance

Peretz (2001) observed this preference in adults as well. Participants were presented with consonant and dissonant melodies, and asked to rate them as “pleasant” or “unpleasant.” A significant correlation was found between consonance and pleasantness, as well as dissonance and unpleasantness. This correlation was again demonstrated in a study by Passynkova, Neubauer, and Scheich (2007). In this study participants listened to consonant, dissonant, and control (combination of both consonance and dissonance) blocks of sound, which were rated on scales of both pleasantness and familiarity. The consonant blocks of sound were rated significantly higher on both scales, indicating a correlation between consonance and pleasantness, as well as between familiarity and pleasantness.

Neural Responses to Dissonance

Researchers theorize that perceptual analysis of the spectral aspects of musical stimuli that contribute to the experience of consonance and dissonance takes place prior to the formation of conscious emotional qualifications. Through electroencephalography (EEG), the “roughness” of dissonance was examined as related to the oscillatory phase-locking activity of neuronal ensemble responses to the temporal envelope of complex sounds within the primary auditory cortex (Fishman, Volkov, Noh, Garell, Bakken, et. al, 2001). In participants, the phase-locking oscillation was at its peak during the dissonant intervals, which in turn resulted in subjects reporting disliking the excerpts. During the consonant intervals, participants reported enjoying the music, and phase-locking oscillation was much less—nearly non-existent. That is to say that consonant intervals

evoked auditory nerve fiber activity that could be resolved easily, whereas the dissonant intervals contained frequencies that could not be resolved, therefore causing coarse fluctuation. This fluctuation gave way to the perception of roughness or dissonance. In this sense, the adult brain appeared to analyze consonance and dissonance before interpreting it as pleasant or unpleasant.

Cognitive Responses to Dissonance

This increased phase-locking oscillation found in the prior study may also result in improved cognition through increased arousal. Bodner, Gilboa, and Amir (2007) completed a large-scale study with over 200 undergraduate non-musicians. The participants were divided into three groups: those listening to consonant music, those listening to dissonant music, and those listening to no music. The groups were then given cognitive tasks. There was an underlying assumption that the dissonant music would decrease participants' motivation and cognitive ability, however this assumption was not supported by the results. The dissonance group showed superiority to the consonance group on cognitive tasks. One possible explanation was that the dissonant music heightened participants' arousal, allowing their peak performance. This study considered the positive effect dissonance may have on cognitive ability.

Physiological Responses to Dissonance

Electrodermal Activity

In addition to behavioral and cognitive research on reactions to dissonance, several studies have observed physiological reactions. For example, electrodermal

activity (EDA) is an increase in the electrical conductivity of the skin, coupled with increased sweat gland activity and changes in peripheral tone (Dawson, Schell, & Courtney, 2011). An increase in EDA is presumed to be associated with both arousal and displeasure, and has thus been linked to negatively-valenced music and dissonance (Cacioppo et al., 2000; Baumgartner, Esslen & Jancke, 2005; Nater et al., 2006; Steinbeis, Koelsch, & Sloboda, 2006; Dellacherie et al., 2010).

A 2005 study utilized musical excerpts specifically chosen to evoke fear, sadness, and happiness in participants. Appropriate visual stimuli were paired with each emotion. As expected, EDA decreased during the happiness condition, and increased during the two negatively-valenced conditions—fear and sadness, further validating the utilization of EDA as an indicator of emotion (Baumgartner, Esslen & Jancke, 2005). This concept was revisited in a study utilizing positively-valenced (Renaissance) and negatively-valenced (heavy metal) musical conditions. These two excerpts were rated by subjects not participating in the actual experiment. Once again EDA was significantly higher during the negatively-valenced music (Nater et al., 2006).

Because EDA has also been utilized as an indicator of arousal, it was employed by a study measuring physiological reactions to unexpected events in music. Six Bach chorales were used as stimuli, and each one either proceeded as written or contained an unexpected or very unexpected harmonic violation. EDA increased with harmonic unexpectedness in both musicians and nonmusicians during this study (Steinbeis, Koelsch, & Sloboda, 2006). The role of harmonic unexpectedness factored into the study after which the current study was modeled, which found that EDA significantly increased during dissonant excerpts in both musicians and nonmusicians (Dellacherie et al., 2010).

Facial Electromyography

In addition to EDA, facial electromyography (EMG) has been recently utilized as an indicator of emotion. The two types of EMG responses measured in this study were on the corrugator and zygomatic muscles. The corrugator muscle region (corrugator supercilii), located over the brow and activated when frowning, has consistently been activated as the result of negatively-valenced situations. Though not as consistently accurate, the zygomatic muscle region (zygomaticus major), located in the cheek and activated when smiling, has been used as a measure of reactions to positively-valenced situations (Cacciopo et al., 2000). However the zygomatic muscle activity is sometimes elevated during negatively-valenced situations as well. This is thought to be a self-regulatory response to distressing situations, or an ironic smile or grimace (Ansfield, 2007). A recent study had participants view either a pleasant or sad excerpt from a movie. Individuals viewing the pleasant excerpt showed increased zygomatic muscle activity, whereas individuals viewing the sad excerpt showed increased corrugator muscle activity. Moreover, these results corresponded with participants' self-reports, therefore supporting the usage of facial EMG to indicate emotion (Silvestrini & Gendolla, 2009).

Two separate studies observed facial EMG reactivity to different kinds of music. Roy et al. (2009) found that when listening to "unpleasant" music, participants showed significantly more activity in the corrugator muscle. However, results regarding the zygomatic muscle were mixed. It was hypothesized that this was due to the zygomatic muscle's tendency to be activated by so many different mood states. The findings of

Dellacherie et al. (2010) essentially mirror these results. In this study, both musicians and nonmusicians listened to consonant and dissonant excerpts of music. Both groups experienced increased corrugator activity during the dissonant excerpts. However the musicians in the study experienced increased zygomatic activity during the dissonant excerpts, contrary to previous indications. These were thought to be negative or surprised reactions expressed in the form of a grimace or laughter, though further study would be needed to determine specific causality.

Effect of Musical Training on Response to Dissonance

Although the preference for consonance over dissonance appears to be present in most individuals, it seems that musicians react more strongly to dissonance than nonmusicians do, based on both self-report and physiological responses (Bigand, Parncutt & Lerdahl, 1996; Bigand & Parncutt, 1999; Schon et al, 2005; Pallesen et al., 2005; Brattico et al., 2008; Minati et al., 2009; Dellacherie et al., 2010). It has been hypothesized that music experience facilitates the processing of dissonance, thereby musicians are more prone to be affected by it (Dellacherie et al., 2010; Makowski & Epstein, 2012).

Effect of Musical Training on Neurological Response to Dissonance

Musical training appears to actually change the way the brain responds to musical stimuli. Years of musical study and practice mold a more sophisticated auditory system by priming the primary auditory cortex for musical analysis. This makes musicians more capable of extracting pertinent information when listening to musical stimuli (Dawson,

2012). Musicians' brains also display more bilateral neural connections than nonmusicians' (Steinbeis, Koelsch, & Sloboda, 2006; Patston, Hogg, & Tippet, 2007; Brattico et al., 2008; Minati et al., 2009), which may be why musicians respond more strongly (both neurologically and physiologically) to violations in musical expectations.

Effect of Musical Training on Subjective Response to Dissonance

The difference in how musicians and nonmusicians react to musical dissonance correlates strongly with studies involving self-reports of reactions to, and identification of, different musical stimuli. As might be expected, musicians can more accurately identify dissonance in both chord sequences and isolation (Bigand & Parncutt, 1996; Schon et al., 2005; Minati et al., 2009). In three studies involving self-reports, musicians rated dissonant excerpts as more unpleasant than did their nonmusician counterparts (Pallesen et al., 2005; Schon et al., 2005; Dellacherie et al., 2010). Because musicians spend time taking lessons and honing their musical skills, when they hear familiar music with altered harmonies, they may automatically label those as “wrong notes,” therefore making their subjective responses dissonance more extreme than those of nonmusicians.

Effect of Musical Training on Physiological Response to Dissonance

This ability to identify dissonance, along with its association with tension and unpleasantness is thought to affect musicians' physiological responses to dissonance. Dellacherie et al. (2010) investigated this hypothesis by presenting both musicians and nonmusicians with consonant and dissonant excerpts of music. Not only did musicians describe the dissonant excerpts as more unpleasant, they also displayed more pronounced

reactions in both EDA and corrugator EMG than did the nonmusicians. Additionally musicians showed increased activation of the zygomatic region during the dissonant excerpts (contrary to expectations), thought to be influenced by ironic smiling or laughing.

Summary

Several studies have investigated individuals' self-reported, neurological, and physiological reactions to consonance and dissonance. Of these studies, the majority have reported that individuals find dissonance to be more unpleasant than consonance. Two physiological measures commonly utilized in these studies include EDA, which is thought to increase during negatively-valenced situations, and facial EMG. Facial EMG has been measured using the corrugator (brow) region, which typically is activated during displeasure, and the zygomatic (cheek) region, which is typically activated during enjoyable situations (although it can be activated as a negative reaction under certain circumstances). Additionally, research findings indicate that musicians respond more strongly to dissonance than do nonmusicians, due to training. Considering previous research findings, it was hypothesized that dissonance would be reported as more unpleasant than consonance. It was also predicted that EDA and corrugator activity would increase during dissonance, while zygomatic activity will increase during consonance. It was hypothesized that musical experience would affect both self-reports and physiological measures, with musicians displaying more pronounced results.

CHAPTER III

METHOD

Participants

The study closely followed the procedure as outlined by Dellacherie et al. (2010). Thirty participants, aged 19-51, were recruited among students attending Western Michigan University (WMU) in Kalamazoo, MI. In order to recruit participants, instructors of summer courses in both music and psychology were contacted and asked to forward an approved recruitment email (see Appendix A) to their students. The recruitment email offered participants financial compensation, in the form of a \$10 gift card to Target or amazon.com, for their time. It was noted on the recruitment email that if more than 35 students responded to recruitment, there was a possibility that some students would not be asked to participate. When participants responded to the recruitment email, a follow-up email with further information (see Appendix B) was sent to determine a convenient time.

To determine sample size, β was set at 0.80 and α was set at 0.05, with a large effect size anticipated. Previous research (Dellacherie et al., 2010) indicated that a study utilizing these physiological measures and variables would result in a large effect with a sample of 25-30 participants. The precision of the physiological measurement employed in this study also contributed to the determination of sample size.

Each participant completed a researcher-created questionnaire (see Appendix D) based on the criteria utilized in Dellacherie's study (2010) to determine their prior musical experience, and test for homogeneity of samples. The questionnaire included questions regarding listening habits, level and depth of music education, current practice

habits, and musical preference. Participants were labeled as having high musical experience (HE) or low musical experience (LE), based on their responses to the questionnaire.

Thirty individuals participated in this study (see Table 1). The pool of HE participants consisted of 16 individuals. Fifteen were music majors. One was an Occupational Therapy major with ten years of institutional music training, who continued to practice music on a regular basis. The HE participants consisted of six males and ten females, who had 2-14 years of institutional training. Fifteen of the HE participants reported attending a live music event at least once a month. The other 14 participants (11 female, 3 male) were labeled as LE. Only two of these participants had received institutional training, and both reported that training as being in the past. Only one LE participant reported attending at least one live musical performance per month. Please see Appendix I for further information regarding majors, listening habits, and additional demographics of participants.

Table 1

Age and Gender of Participants

	Males	Females	Minimum Age (yrs)	Maximum Age (yrs)	Mean Age (yrs)	Standard Deviation
LE Participants	3	11	19	51	26.1	8.3
HE Participants	6	10	19	28	22.7	3.0

Participants were given a chance to sit and habituate to the environment upon arrival, especially if they appeared to be tired. All participants signed informed consent forms (see Appendix C) prior to participation in this study.

Auditory Test Stimuli

The ten excerpts of classical music utilized in the current study were selected from the same list of excerpts used in Dellacherie's (2010) study. That list of 16 excerpts had been compiled for prior studies with similar need for "pleasant" music (Gosselin, Samson, Adolphs, Noulhane, Roy, et al., 2006; Khalfa, Guye, Peretz, Chapon, Girard, et al., 2008; Peretz et al., 2001; Peretz, Gagnon, & Bouchard, 1998) (see Appendix E). In the present study, 10 of these 16 excerpts were selected based on the presence of a distinct melodic line (see Table 2).

Table 2

Selected Excerpts

Composer	Work	Measures	Tempo (bpm)
Beethoven	Symphony no. 3 (3 rd mvt)	38-56	180
Handel	Utrecht's Te Deum	5-14	112
Mozart	Eine Kleine Nachtmusik (1 st mvt)	5-10	154
Mozart	Piano Concerto no. 23 (3 rd mvt)	1-8	240
Saint-Saëns	Carnaval des Animaux (Finale)	10-26	220
Saint-Saëns	Carnaval des Animaux (La Voliere)	1-9	88
Schumann	Kinderszenen (Op 15 no. 9)	1-9	240
Verdi	La Traviatta (Brindisi)	1-15	100
Verdi	Rigoletto (Act 1 no. 4)	69-73	150
Vivaldi	L'Autunno (1 st mvt)	1-4	126

All stimuli were traditionally instrumental (i.e., no lyrics) and selected to evoke happiness. Each excerpt was seven seconds long, and delivered with a piano timbre. Excerpts were recorded into GarageBand software on the “Grand Piano” setting using a MIDI keyboard. Each of the ten excerpts was modified by shifting the pitch of the leading tones upward one semitone and downward one semitone, therefore creating 20 dissonant versions of the original 10 consonant excerpts. Each consonant excerpt was presented twice to match the number of dissonant excerpts.

Research Design

Procedure

Each participant began his/her individual session by completing the informed consent form and musical experience questionnaire. Then the physiological sensors were attached to the individual to measure EDA and facial EMG. A hand-grip squeeze task was used to test that EDA measures were functioning properly. That is, each participant was asked to make a tight fist with his/her dominant hand to raise his/her EDA, which caused a visible response on the monitoring screen. Each participant was given four pleasantness rating sheets (see Appendix F), which were explained at that time. The preliminary portion of the study took approximately 30 minutes.

The format of each listening block proceeded as follows (Dellacherie et al., 2010). Each listening block started with a loud burst of white noise (50 ms, 90 db) followed by a 10-second recovery period as an index of individual EDA and startle response. That was followed by ten excerpts in randomized alternating order, balanced between consonant and dissonant excerpts. Individual excerpts were presented as follows:

- 1) verbal reminder not to move (2 seconds)
- 2) rest period (7 seconds)
- 3) consonant or dissonant excerpt (7 seconds)
- 4) rest period (1-2 seconds)
- 5) verbal confirmation of allowed movement (2 seconds)
- 6) self-report of pleasantness (10 seconds)

This process took place for ten excerpts, which were randomized and balanced between consonant and dissonant excerpts. After each cycle of ten excerpts, participants were given twenty seconds to rest or move if they desired to do so. This full cycle took place four times, encompassing twenty dissonant and ten repeated consonant excerpts. The experimental process lasted approximately 22 minutes. Taking into consideration the 30 minutes allotted for initial documentation and preliminary measures, each data collection trial lasted approximately one hour.

Measures

Electrodermal activity was continuously measured using the MP150 Biopac system available in the BRAIN lab at Western Michigan University. Electrodermal Activity (EDA) Disposable Electrodes (BioNomadix EL507) were attached to the index and middle finger on participants' non-dominant hands (to allow them to fill out pleasantness ratings with their dominant hands). The signal was filtered between 0.05 and 10 Hz. Disposable cloth electrodes (BioNomadix EL504-10) were attached at both the corrugator (brow) and zygomatic (cheek) regions. They were monitored continuously using the Biopac system, filtered between 100 and 500 Hz. All measurements were taken

at a sampling rate of 2000 Hz and processed using the available AcqKnowledge software. These measurement devices were noninvasive, and took little time to apply. The only known side effects participants experienced were small marks on the skin that quickly faded. Subjective ratings were gathered by prompting participants to rate their perceived pleasantness of each excerpt on a scale of -5 (most unpleasant) to 5 (most pleasant) (see Appendix F).

At the end of the four listening blocks electrodes were removed from the participants, and they were thanked and compensated. Because this study required each participant to engage in the experiment only once, no follow-up was necessary.

CHAPTER IV

RESULTS

The purpose of this study was examine the presumed preference for consonance over dissonance, as well as to explore the effect of musical training on subjective ratings and physiological responses to consonant and dissonant excerpts of music. Research questions were as follows:

- 1a. Will dissonant excerpts produce more negatively-valenced subjective ratings than consonant excerpts?
- 1b. Will subjective ratings of dissonant and consonant excerpts differ between musicians and nonmusicians?
2. Will dissonant excerpts increase electrodermal activity to a greater degree than consonant excerpts?
3. Will dissonant excerpts increase corrugator muscle activation to a greater degree than consonant excerpts?
4. Will consonant excerpts increase zygomatic muscle activation to a greater degree than dissonant excerpts?
5. Will physiological responses differ between musicians and nonmusicians?

Although both the physiological and self-report measures were acquired through these trials, for the scope of this thesis project, and due to the amplitude of the gathered data, only the self-report measures (research questions 1a and 1b) were analyzed. It is intended that research questions 2-5 will be examined in future analysis.

Research Question #1a

Will dissonant excerpts produce more negatively-valenced subjective ratings than consonant excerpts?

In order to determine whether dissonant excerpts received more negatively-valenced subjective ratings than consonant excerpts, each participant's mean rating for both consonant and dissonant excerpts was calculated. A two-factor, mixed-model ANOVA was run, and it was found that across all subjects, consonant excerpts were rated as significantly more pleasant ($M=2.7$, $SE=.23$) than dissonant excerpts ($M=-.43$, $SE=.36$), $F(1,28)=58.4$, $p<.001$. The range and means of the ratings can be seen in Figure 1.

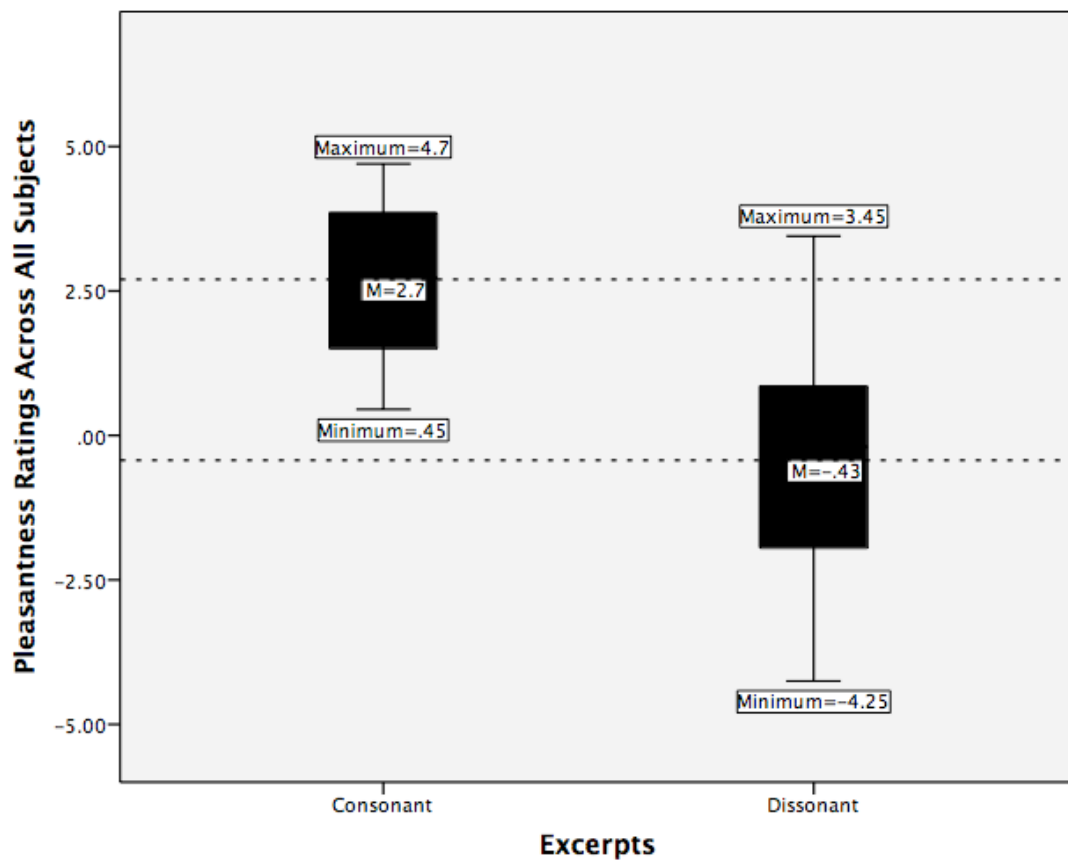


Figure 1. Pleasantness ratings across all subjects for consonant and dissonant excerpts.

Research Question #1b

Will subjective ratings of dissonant and consonant excerpts differ between musicians and nonmusicians?

A two-factor, mixed-model ANOVA was carried out to determine the difference between HE and LE participants' ratings of pleasantness in consonant and dissonant excerpts. On average, HE participants rated consonant excerpts as more pleasant ($M=2.8$) than did LE participants ($M=2.5$). Similarly, HE participants' ratings of dissonance excerpts ($M=-.71$) were, on average, lower than LE participants' ratings ($M=-.11$) (see Figure 2). There was a nonsignificant interaction between musical experience and the type of excerpt being rated, $F(1, 28)=1.47, p=.236$. Therefore, although HE participants rated both excerpt groups more extremely than LE participants, no significant interaction was found.

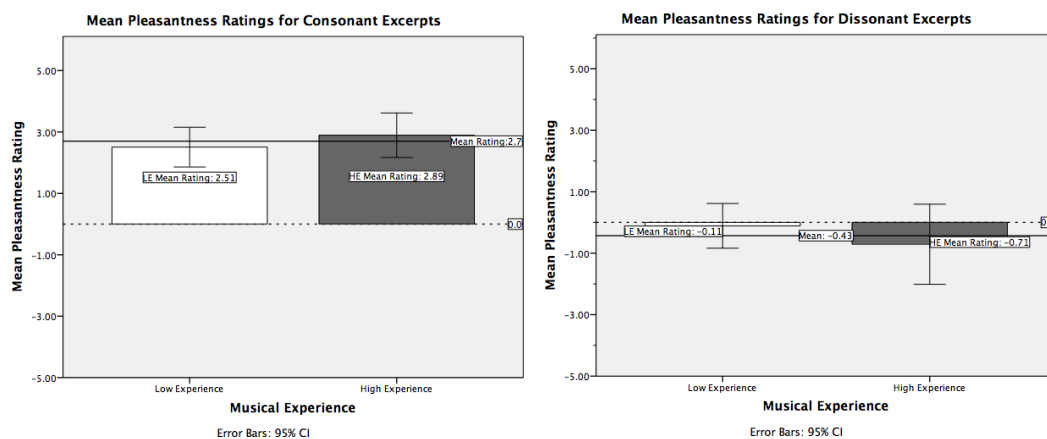


Figure 2. Mean pleasantness ratings for consonant and dissonant excerpts in LE and HE groups

CHAPTER V

DISCUSSION

Consonance and Dissonance

As expected, dissonant excerpts were rated as significantly more unpleasant than consonant excerpts. These results support the findings of multiple other studies (Blood, Zatorre, Bermudez, & Evans, 1999; Koelsch, Fritz, Schulze, Alsop, & Schlaug, 2006, Pallesen et al., 2005; Peretz et al., 2001; Sammler et al., 2007). It has become more apparent that dissonance is perceived more negatively than consonance, most likely even from birth (Trainor & Heinmiller, 1998; Zentner, 1998; Trainor, Tsang & Cheung, 2002; Masataka, 2006). Additionally these findings mirror the results from the study upon which this research was based (Dellacherie et al., 2010). Though this is not new knowledge, the results from the current study provide confirmation of the findings from previously published research in this subject.

Somewhat surprisingly, pleasantness ratings on dissonant excerpts were widely varied, with a range of -4.25 to 3.45. This could be due to the fact that several participants spontaneously stated after their trials that the dissonant excerpts sounded “funny,” and “interesting.” A few HE participants commented that the dissonant excerpts were more interesting to them because they were novel—they were familiar in that they were based on well-known excerpts, but the altered state made them more appealing than their recognizable counterparts. This interest level could account for the higher ratings on dissonant excerpts.

Musical Experience

HE participants did, on average, rate consonant excerpts as more pleasant, and dissonant excerpts as more unpleasant than did LE participants. In the study upon which this thesis project was based, HE participants rated dissonant excerpts as significantly more unpleasant than consonant excerpts (Dellacherie et al., 2010). The lowest mean rating on dissonant excerpts from a LE participant in the current study was -2.6, whereas the lowest mean rating for the dissonant excerpts from a HE participant was the more extreme -4.25. Although the analysis did not yield significant results, it can be seen that HE participants tended more toward the extreme negative ratings on dissonant excerpts than did LE participants. Again, it should be noted that some HE participants relayed their interest in the dissonant excerpts due to their novelty. It is not known whether this was the cause of the more positive ratings for dissonant excerpts in HE participants, but it could be a contributing factor.

Limitations

This thesis project was meant to replicate the 2010 study by Dellacherie, et al. Although an attempt was made, it was not possible to acquire the exact excerpts or names of the pieces utilized in that study. However, the excerpts were acquired from the same list used in prior studies (Gosselin et al., 2006; Khalfa et al., 2008; Peretz et al., 2001; Peretz, Gagnon, & Bouchard, 1998). It is entirely possible that different excerpts were selected from that list, although there was some inevitable overlap, as 10 of the 16 possible excerpts from these previous studies were utilized in each study.

The ecological validity of the auditory stimuli should be considered somewhat weak. Because of the way the melodies were manipulated to create the dissonant stimuli, the resulting excerpts were not typical of what one might find in a dissonant composition. That is to say, certain individuals might genuinely enjoy a contemporary composer's take on dissonance more than the traditional classical pieces with altered melodic lines that were used in this study.

The room in which the participants were exposed to the excerpts was not entirely soundproof. It was behind a closed door, adjacent to the room in which the researcher sat during the trials, and there were no known extraneous noises. Measures were taken to minimize the possibility of external noise (*i.e.*, quality headphones, explanatory sign on the external door) but there was no way to entirely soundproof the area.

Suggestions for Future Research

This study added to the body of research in which individuals found dissonance to be more unpleasant than consonance. In the current study, HE participants rated dissonant excerpts as more unpleasant than LE participants, and consonant excerpts as more pleasant than LE participants. Although these results were not significant, they indicated that there was a difference between the two groups. There is a growing body of research indicating that music education modulates how individuals perceive musical consonance and dissonance (Pallesen et al., 2005; Schon et al., 2005; Dellacherie et al., 2010).

It would be interesting to carry out a similar study with individuals who have been trained in musical genres more defined by dissonance, such as contemporary music or

free jazz. Additional rating scales such as “level of interest” or “arousal” could also add to the research by exploring the varied responses the HE group gave on the dissonant excerpts.

The next step within these trials is to analyze the physiological data. It is anticipated that a fellow graduate student will complete that analysis. Once the analysis for the gathered EDA and EMG data is complete, it will be of considerable interest to see if there is a physiological difference in reactions to consonance and dissonance between HE and LE participants, and if the physiological data correlates with the self-report analysis. The completion of analysis is anticipated to add to the body of research examining the impact music education has on individuals’ perception and reaction to consonance and dissonance.

Appendix A
Recruitment Script

Greetings!

My name is Rebecca J. Bumgarner, and I am a graduate student in music therapy at Western Michigan University. I would like to invite you to participate in my research study “Psychophysiological and Emotional Responses to Musical Dissonance in Musicians and Non-musicians.”

You may participate if you are a student at Western Michigan University, aged 18-99 years.

This study seeks to investigate the effects of musically dissonant sounds on psychophysiological and emotional responses in both musicians and non-musicians.

Your participation will contribute to knowledge concerning physiological reactions to music, and its potential contribution to subsequent clinical research.

Participation in this study will require a one-hour commitment, one time only.

The study will take place in the BRAIN Lab, located in room 2019 on the second floor of the Health and Human Services building.

You will be financially compensated for your participation in the study with a \$10 gift card.

Interested? Please contact me by email (rjbumgarner@gmail.com) or by phone (620-870-0311) for further information.

Thank you in advance for your consideration,

Rebecca J. Bumgarner

Appendix B

Recruitment Follow-up Script

Greetings!

Thank you for your interest in my research study.

Participation in this study will require one hour of your time.

The study involves listening to forty 7-second excerpts of music with a short break between each excerpt.

After each excerpt you will be asked to rate the perceived pleasantness of each excerpt on a numeric scale.

Additionally physiologic measures such as muscle activity and skin conductance will be measured while you are listening to the excerpts.

You will be compensated for your participation in this study with a \$10 gift card.

If you have further questions or require further clarification, please do not hesitate to contact me by email (rjbumgarner@gmail.com) or by phone (620-870-0311).

If you do not have any further questions and are still interested in participating, please choose one of the following times that is convenient for you to participate in my study:

(Insert or state the following two weeks' available dates and times)

Thank you for your interest,

Rebecca J. Bumgarner

Appendix C
Informed Consent Form

**Western Michigan University
School of Music**

Principal Investigator: Edward A. Roth, MM, MT-BC
Student Investigator: Rebecca J. Bumgarner, MT-BC
Title of Study: Psychophysiological and Emotional Responses to Musical Dissonance in Musicians and Non-musicians

You have been invited to participate in a research project titled “Psychophysiological and Emotional Responses to Musical Dissonance in Musicians and Non-musicians.” This project will serve as Rebecca J. Bumgarner’s master’s thesis for the requirements of the Master of Music degree in music therapy. This consent document will explain the purpose of this research project and will go over all of the time commitments, the procedures used in the study, and the risks and benefits of participating in this research project. Please read this consent form carefully and completely and please ask any questions if you need more clarification.

What are we trying to find out in this study?

The purpose of this study is to determine if, and to what extent, musicians respond differently to dissonance in music than non-musicians. Information regarding both self-report and physiological measures will be gathered.

Who can participate in this study?

This study is open to any Western Michigan University student who does not report a hearing impairment that significantly decreases their ability to perceive auditory spectral content. Participants will be categorized as having high experience (HE) or low experience (LE) in music. Experience level will be determined by a brief questionnaire.

Where will this study take place?

All procedures will take place in the BRAIN Lab, located in room 2019 on the second floor of the College of Health and Human Services building at Western Michigan University.

What is the time commitment for participating in this study?

This study requires participants to commit to a one-hour time block, one time only.

What will you be asked to do if you choose to participate in this study?

If you should choose to participate in this study, you will be asked to do the following:

- 1) Complete a brief questionnaire to determine your level of music experience.
- 2) Allow student researcher to place noninvasive electrodes on your brow, cheek, and non-dominant hand.
- 3) Listen to short musical excerpts through headphones while seated.
- 4) Indicate on a numeric scale to what extent you found the excerpts to be pleasant.

What information is being measured during the study?

This section will describe the measurements that we are going to take during your participation in the study.

The two physiological measures that will be obtained include muscle contraction and arousal.

Muscle contraction will be measured via noninvasive facial electromyography (EMG). Electrodes will be placed both between your eyebrows and on your cheek.

Electrodes will also be placed on the pointer finger and at the base of your thumb on your non-dominant hand. These will measure skin conductance response, which when increased, is identified as an indication of arousal.

Additionally you will be asked to indicate on a numeric scale to what extent you found the excerpts to be pleasant

What are the risks of participating in this study and how will these risks be minimized?

The only potential risk of participating in this study is the possibility of a minor skin irritation related to the electrodes. The risk, already minimal, will be further minimized by proper usage of electrode gel and placement. There are no known risks associated with the listening task.

What are the benefits of participating in this study?

There are no known direct benefits of participating in this study. Your participation will contribute to knowledge concerning physiological reactions to music, and its potential contribution to subsequent clinical research.

Are there any costs associated with participating in this study?

The only cost associated with participation in this study is one hour of time.

Is there any compensation for participating in this study?

You will be compensated with a \$10 gift card for your participation in this study.

Who will have access to the information collected during this study?

Only the principal investigator and student investigator will have access to the information collected during this study. Your data will be de-identified and stored in a locked cabinet in the principal investigator's office.

What if you want to stop participating in this study?

You can choose to stop participating in the study at anytime for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience no consequences either academically or personally if you choose to withdraw from this study.

The investigator can also decide to stop your participation in the study without your consent.

Should you have any questions prior to or during the study, you can contact the principal investigator, Edward A. Roth at 269-387-5415 or edward.roth@wmich.edu or the student investigator, Rebecca J. Bumgarner at 620-870-0311 or rjbumgarner@gmail.com. You may also contact the Chair, Human Subjects Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study.

This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

I have read this informed consent document. The risks and benefits have been explained to me. I agree to take part in this study.

Please Print Your Name

Participant's signature

Date

Appendix D

Music Experience Questionnaire

Participant #:

Gender:

Age:

Year in college:

Major/Minor:

1. Have you received institutional training in music? ☐ Yes ☐ No
 - a. How many years? _____
2. Have you received music lessons in the past three years? ☐ Yes ☐ No
 - a. ☐ Vocal (part?) _____
 - b. ☐ Instrumental (instrument/s?) _____
3. Approximately how many hours per week do you practice music? _____
4. Are you self-educated in music? ☐ Yes ☐ No
 - a. Please explain _____
5. Approximately how many hours per week do you listen to music? _____
6. Approximately how many hours per week do you listen to music with attention (*i.e.*, not just as background to driving/doing chores/etc)? _____
7. On average, do you attend at least one live music event per month?

☐ Yes
 ☐ No

 - a. What type of concerts (*e.g.*, symphony, rock, jazz)? _____
8. Please mark any music genres you regularly listen to and enjoy:

- ☐ Popular

☐ New Age

☐ Country/Folk

☐ Rock

☐ Gospel/Contemporary Christian

☐ Musicals/Showtunes

- ☐ Rap/Hip-Hop

☐ Classical

☐ Atonal/Avant-garde

☐ Jazz/Swing

☐ Free Jazz

☐ Other _____

Appendix E

Listening Excerpts from Prior Studies

Listening Excerpts from Prior Studies

Composer	Work	Measure ^a	M.M.f	Key	Instrumentation	Emotion
Beethoven	Piano Concerto no. 4 (3rd mvt)	191– 200(2)	150	G Maj	Piano and orchestra	Happy
Beethoven	Piano Concerto no. 4 (3rd mvt)	439– 452(2)	150	G Maj	Piano and orchestra	Happy
Beethoven	Symphony no. 3 (3rd mvt)	38–56	180 ^b	F Maj	Orchestra	Happy
Beethoven	Symphony no. 6 (3rd mvt)	9(3)– 16(1)	240	D Maj	Orchestra	Happy
Haendel	Utrecht's Te Deum	5–14(1)	112	D Maj	Orchestra	Happy
Mozart	Die Zauberflöte (Act 1 no. 2 Papageno's Aria)	18(2)– 24(2)	80	G Maj	Orchestra	Happy
Mozart	Eine kleine nachtmusik (1st mvt)	5(3)– 10(3)	154	G Maj	String orchestra	Happy
Mozart	Piano Concerto no. 23 (3rd mvt)	1–8	255	A Maj	Piano	Happy
Mozart	Piano Concerto no. 27 (3rd mvt)	1–8	167	B flat Maj	Piano and orchestra	Happy
Ravel	Tombeau de Couperin (Rigaudon)	Bar1–9(2)	100	C Maj	Piano	Happy
Saint-Saëns	Carnaval des Animaux (Finale)	10–26(4)	220	C Maj	Piano and orchestra	Happy
Saint-Saëns	Carnaval des Animaux (La volière)	1–9(2)	88	F Maj	Piano and orchestra	Happy
Schumann	Kinderszenen (Op 15 no. 9)	1–9	240	C Maj	Piano	Happy
Verdi	La Traviatta (Brindisi)	1–15(1)	100	B flat Maj	Orchestra	Happy
Verdi	Rigoletto (Act 1 no. 4)	69–73	150	C Maj	Orchestra	Happy
Vivaldi	L'Autunno (1st mvt)	1(2)–4(3)	126	F Maj	Orchestra	Happy

(Peretz, Gagnon, & Bouchard, 1998, p. 140)

Appendix F

Pleasantness Rating Scale

Participant #:

Listening Block:

Perceived Pleasantness

Please rate each excerpt on a scale of -5 (very unpleasant) to 5 (very pleasant), by circling the appropriate rating when prompted.

Unpleasant

Pleasant

1.	-5	-4	-3	-2	-1	0	1	2	3	4	5
2.	-5	-4	-3	-2	-1	0	1	2	3	4	5
3.	-5	-4	-3	-2	-1	0	1	2	3	4	5
4.	-5	-4	-3	-2	-1	0	1	2	3	4	5
5.	-5	-4	-3	-2	-1	0	1	2	3	4	5
6.	-5	-4	-3	-2	-1	0	1	2	3	4	5
7.	-5	-4	-3	-2	-1	0	1	2	3	4	5
8.	-5	-4	-3	-2	-1	0	1	2	3	4	5
9.	-5	-4	-3	-2	-1	0	1	2	3	4	5
10.	-5	-4	-3	-2	-1	0	1	2	3	4	5

Unpleasant

Pleasant

Appendix G
LE Subjective Ratings

		Participant 5	Participant 6	Participant 16	Participant 19	Participant 21	Participant 22	Participant 23
1-1	C	2	4	4	3	2	5	5
1-2	D	2	1	3	4	2	3	4
1-3	C	4	1	4	4	3	5	4
1-4	C	1	2	4	2	1	5	4
1-5	D	1	2	2	2	0	-1	5
1-6	C	2	3	5	4	4	5	5
1-7	D	1	1	0	2	0	-1	3
1-8	D	1	0	2	3	-2	0	-1
1-9	C	1	0	3	3	-1	4	3
1-10	D	0	0	0	1	-2	-1	-3
2-1	D	1	0	0	-1	-3	-1	-2
2-2	C	1	1	1	2	2	3	5
2-3	D	0	0	-1	-2	-1	1	3
2-4	C	0	0	2	2	1	5	3
2-5	C	1	0	4	3	2	5	4
2-6	D	0	1	3	1	-4	1	-3
2-7	C	1	1	5	4	3	5	5
2-8	D	0	0	2	-3	-1	-1	-3
2-9	D	2	-1	1	0	0	0	4
2-10	C	1	0	1	0	4	3	5
3-1	C	1	1	4	0	1	4	4
3-2	D	0	-2	1	-3	1	-1	-4
3-3	C	1	0	2	-1	3	4	3
3-4	C	0	2	-1	1	2	4	4
3-5	D	0	2	-2	0	3	2	5
3-6	C	2	3	3	2	3	5	4
3-7	D	1	-1	3	-3	3	1	-4
3-8	D	0	3	1	-2	-1	0	4
3-9	C	0	1	4	0	3	4	4
3-10	D	1	2	2	2	4	2	3
4-1	D	0	1	0	1	-1	2	5
4-2	C	0	1	2	3	1	2	4
4-3	D	1	-1	-1	-1	0	1	-4
4-4	C	0	1	4	2	3	4	4
4-5	C	0	1	2	0	2	4	3
4-6	D	-1	-3	0	-4	-2	3	-4
4-7	C	0	1	2	2	0	3	4
4-8	D	-1	-1	3	-3	-2	2	-4
4-9	D	-1	-4	-1	-1	-3	1	-5
4-10	C	2	2	-2	1	0	5	4

		Participant 24	Participant 25	Participant 26	Participant 27	Participant 28	Participant 29	Participant 30
1-1	D	-4	0	2	-3	0	0	2
1-2	C	4	0	3	5	5	3	3
1-3	D	2	-2	-1	3	4	0	0
1-4	C	5	2	0	3	2	2	3
1-5	C	-1	3	2	2	5	3	2
1-6	D	-3	1	-1	-1	5	-3	4
1-7	C	5	3	5	5	5	4	4
1-8	D	-5	-2	2	-2	1	-1	0
1-9	D	4	0	3	2	5	0	3
1-10	C	4	-1	4	3	5	1	1
2-1	C	5	1	3	3	5	2	3
2-2	D	-5	2	0	-3	-1	3	3
2-3	C	3	4	5	3	4	3	3
2-4	C	5	-1	4	2	4	1	2
2-5	D	-2	0	-1	-1	3	4	2
2-6	C	5	4	5	5	5	4	4
2-7	D	1	-2	-2	-3	-1	-2	1
2-8	D	-5	-1	-2	-4	0	1	1
2-9	C	4	-1	3	2	5	0	4
2-10	D	-5	0	-1	-5	2	3	1
3-1	D	3	0	-1	-1	1	-1	1
3-2	C	2	0	-1	-2	3	3	3
3-3	D	-3	-1	-2	-2	2	2	1
3-4	C	5	4	2	4	5	3	3
3-5	C	0	-1	1	2	3	-2	0
3-6	D	-5	2	-3	-4	3	4	3
3-7	C	4	-1	3	3	5	-3	3
3-8	D	-5	-4	-3	-5	0	0	-1
3-9	D	-5	1	-5	-5	-2	2	-1
3-10	C	5	-1	4	1	4	-1	4
4-1	C	-1	0	-2	1	4	3	1
4-2	D	-5	-1	-4	-5	-2	2	-1
4-3	C	5	2	3	-1	5	2	3
4-4	C	0	2	3	5	3	-3	3
4-5	D	-2	-2	4	-2	4	-2	3
4-6	C	3	2	2	-1	3	4	3
4-7	D	-5	2	0	-5	2	3	2
4-8	D	1	-2	-4	-5	4	-2	3
4-9	C	5	4	3	3	5	1	4
4-10	D	-1	-3	4	-1	3	-2	4

Appendix H

HE Subjective Rating

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 7	Participant 8	Participant 9
1-1	3	4	5	4	4	3	5
1-2	-4	2	-2	-2	-2	3	5
1-3	2	1	4	3	-1	2	4
1-4	3	1	5	3	3	3	4
1-5	-3	2	-3	-1	-3	4	1
1-6	3	1	5	5	5	2	4
1-7	-5	-3	-2	-3	-4	3	2
1-8	-4	0	-1	-3	-4	4	1
1-9	-1	3	4	3	5	4	5
1-10	-5	-1	-3	-3	-5	3	2
2-1	-5	-3	-3	-4	-3	3	0
2-2	4	2	5	5	5	4	5
2-3	-4	-2	-1	1	-4	3	2
2-4	1	2	4	3	3	3	3
2-5	4	3	4	4	2	4	4
2-6	-3	0	-3	-3	-4	4	3
2-7	3	2	5	5	5	3	4
2-8	-5	-3	-2	0	-4	4	5
2-9	-3	-2	3	3	-1	3	5
2-10	4	-1	5	4	-3	3	4
3-1	4	-1	4	3	2	3	4
3-2	-5	-2	-4	-4	-5	3	1
3-3	3	0	5	3	1	4	4
3-4	3	-3	5	4	-2	4	3
3-5	-4	1	-1	-1	-3	3	2
3-6	2	1	5	2	4	2	4
3-7	-5	1	-1	-3	-4	3	4
3-8	-4	-1	-1	-3	-5	4	2
3-9	3	2	4	2	-3	4	5
3-10	-4	1	4	2	-2	3	4
4-1	-5	-4	-1	-3	-4	3	2
4-2	4	1	5	3	-3	4	4
4-3	-4	2	-1	-4	-3	4	1
4-4	3	2	5	3	-2	3	5
4-5	1	-3	5	4	-4	3	3
4-6	-5	1	-1	-4	-5	4	2
4-7	4	3	5	2	-5	4	4
4-8	-3	-2	-1	0	-5	4	0
4-9	-5	-3	-1	-4	-5	4	1
4-10	0	2	5	4	3	3	5

		Participant 10	Participant 11	Participant 12	Participant 13	Participant 14	Participant 15	Participant 17
1-1	D	-3	-2	0	3	2	3	4
1-2	C	3	4	5	2	4	5	5
1-3	D	-5	3	2	-1	3	4	2
1-4	C	2	4	5	0	2	5	3
1-5	C	4	5	5	1	4	5	4
1-6	D	-3	-3	3	2	3	2	5
1-7	C	3	4	5	3	4	5	4
1-8	D	-5	-2	1	4	3	3	3
1-9	D	2	3	-2	2	3	4	5
1-10	C	1	3	5	3	4	5	5
2-1	C	1	3	5	1	4	5	5
2-2	D	-4	-3	1	-2	1	2	4
2-3	C	5	5	5	0	3	4	4
2-4	C	4	4	5	3	4	4	5
2-5	D	-5	-4	3	-1	0	-1	4
2-6	C	5	4	5	2	5	5	3
2-7	D	-5	-3	1	-1	0	1	0
2-8	D	-4	-4	0	-1	0	-1	0
2-9	C	1	4	-1	0	2	3	3
2-10	D	-5	-4	-1	2	0	-1	-1
3-1	D	-5	-1	2	2	-1	-1	-1
3-2	C	3	4	5	-1	1	-3	3
3-3	D	-4	-3	3	-2	-1	4	-4
3-4	C	4	4	5	1	4	5	5
3-5	C	3	1	5	1	1	5	-3
3-6	D	-5	-4	3	-2	0	1	-4
3-7	C	4	5	5	1	2	5	5
3-8	D	-4	-3	-1	3	3	1	-5
3-9	D	-5	-4	-2	-2	1	-1	-4
3-10	C	2	4	3	-1	2	4	2
4-1	C	2	4	5	3	3	4	1
4-2	D	-5	-4	-1	-1	0	-1	-5
4-3	C	3	5	5	0	3	5	3
4-4	C	2	2	3	-1	0	5	3
4-5	D	-3	3	1	-1	-1	-2	-5
4-6	C	4	4	5	0	2	5	5
4-7	D	-5	-2	2	1	0	-1	-5
4-8	D	-5	-5	2	-1	-1	-2	-5
4-9	C	5	4	5	2	4	4	5
4-10	D	1	2	1	1	2	3	2

Appendix I

Participant Demographics

Low Experience Group

Participant	Gender	Age	Major	Years Institutional Training	Practice hrs /week	Listen hrs/week	Listen w/ attention hrs/week	Attend Live music at least 1X/month?
5	F	22	Human Resources	0	0	7	1	N
6	F	29	IT/a	0	0	6	3	N
16	F	19	Behavioral Science	0	0	10-15	8	N
19	F	21	Psychology	0	0	15	2	N
21	F	24	Public Relations	0	0	10	0	N
22	F	20	Psychology/Communication	0	0	20	0	N
23	M	51	Psychology	0	0	10	0	N
24	F	22	Occupational Therapy	0	0	7-10	0	N
25	F	31	Psychology	0	0	20	5	N
26	M	30	Occupational Therapy	0	0	5	0	N
27	F	23	Occupational Therapy	1, in the past	1-2	30	10	Y
28	F	25	Occupational Therapy	6, in the past	0	5	0	N
29	M	30	Computer Science	0	0	6	0	N
30	F	19	Statistics	0	0	17	15	N

High Experience Group

Participant	Gender	Age	Major	Years Institutional Training	Practice hrs /week	Listen hrs/week	Listen w/ attention hrs/week	Attend Live music at least 1X/month?
1	M	28	Music Performance	4	4	15	5	Y
2	F	22	Music Therapy	4	7-14	28	7	Y
3	M	22	Music Education	4	5	10	2	Y
4	M	21	Performance/Music Education	4	4	56	2	Y
7	F	19	Music Performance	2	14	15	2	Y
8	F	20	Composition	6	15-20	20	4-7	Y
9	F	23	Jazz Studies	10	25	25	25	Y
10	F	21	Music Education	3	8-10	5	1	Y
11	F	21	Music Therapy	14	14	28	3	Y
12	F	21	Bachelor of Arts in Music	4	10	30	2	Y
13	M	20	Composition	7	4	6	2	Y
14	M	27	Music Performance	7	5	6	5	Y
15	F	22	Music Performance	6	35	50	45	Y
17	F	27	Music Therapy	9	10	14	1	N
18	F	21	Occupational Therapy	10	5	20	3	Y
20	M	28	Music	6.5	2-3	20	8	Y

Appendix J

HSIRB Approval and Extension

Date: April 22, 2013

To: Edward Roth, Principal Investigator
Rebecca Bumgarner, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair

Re: HSIRB Project Number 13-03-32

This letter will serve as confirmation that your research project titled “Ed” has been **approved** under the **expedited** category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes in this project (e.g., ***you must request a post approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study.”*** Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: April 22, 2014

WESTERN MICHIGAN UNIVERSITY
Human Subjects Institutional Review Board
 WMU Mail Stop: 5456 Phone: (269) 387-8293

APPLICATION FOR CONTINUING REVIEW OR FINAL REPORT FORM

In compliance with Western Michigan University's policy that "the HSIRB's review of research will be conducted at appropriate intervals but not less than once per year," the HSIRB requests the following information:

PROJECT INFORMATION

PROJECT TITLE: Psychophysiological and Emotional Responses to Musical Dissonance in Musicians and Non-Musicians

HSIRB Project Number: 13-03-32

Date of Last Approval (Initial or Continuing Review): 04/22/13

Previous level of review: ☐ Full Board Review ☒ Expedited Review ☐ Administrative (Exempt) Review

INVESTIGATOR INFORMATION

PRINCIPAL INVESTIGATOR OR ADVISOR

Name: Edward Roth

Department: MUSIC Mail Stop: 5434

Electronic Mail Address: edward.roth@wmich.edu

CO-PRINCIPAL OR STUDENT INVESTIGATOR

Name: Rebecca Bumgarner

Department: MUSIC Mail Stop: 5434

Electronic Mail Address: rebecca.j.bumgarner@wmich.edu

CO-PRINCIPAL OR STUDENT INVESTIGATOR

Name:

Department:

Mail Stop:

Electronic Mail Address:

CURRENT STATUS OF RESEARCH PROJECT

Please answer questions 1-5 to determine if this project requires continuing review by the HSIRB.

1. Has subject recruitment begun? If no, please provide an explanation ☒ Yes ☐ No
 2. Is the project closed to recruitment of new subjects?
☒ Yes (Date of last enrollment: 7/2013) ☐ No (Project must be reviewed for renewal.)
 3. Have all subjects completed research related interventions?
☒ Yes ☐ Not Applicable ☐ No (Project must be reviewed for renewal.)
 4. Has long-term follow-up of subjects been completed?
☒ Yes ☐ Not Applicable ☐ No (Project must be reviewed for renewal.)
 5. Has analysis of data been completed?
☐ Yes ☒ No (Project must be reviewed for renewal.)
- If you have answered "No" to ANY of the questions above, you must apply for **Continuing Review**.
 - *If you need to make changes in your protocol, please submit a separate memo detailing the changes that you are requesting.*
 - If you have answered "Yes" or "Not Applicable" to ALL of the above questions, the project may be closed.
 If the project is closed please use this form for the "Final Report."

☒ **Application for Continuing Review**

☐ **Final Report**

Revised 06/2013 WMU HSIRB (all other copies obsolete).

HSIRB Project Number: 13-03-32

6. Are there any changes in study personnel (add or remove investigators) not previously reported to the HSIRB? ☐ Yes ☒ No
 If you need to add an investigator, provide details on an "Additional Investigator(s) Form" (available at <http://www.wmich.edu/research/forms/complianceforms.html>).
 To remove an investigator submit a memo to the HSIRB detailing the change.
7. Since the last approval (initial or continuing review) has there been any modifications or additions to the protocol, not previously reported to the HSIRB to with respect to the following?
- | | | |
|--------------------|------------------------------|--|
| a. Procedures | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| b. Subjects | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| c. Design | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
| d. Data collection | <input type="checkbox"/> Yes | <input checked="" type="checkbox"/> No |
8. Has any instrumentation been modified or added to the protocol that has not already been approved by the HSIRB? ☐ Yes ☒ No
 If **yes**, attach new instrumentation and a memo indicating the modifications made.
9. Are there changes to the consent/assent form not previously reported to the HSIRB? ☐ Yes ☒ No
 If **yes**, attach new consent/assent form and a memo indicating changes made.

Verification of Consent Procedure: Provide copies of the whole consent documents signed by the last two subjects enrolled in the project. Cover the signature in such a way that the name is not clear but there is evidence of signature. If subjects are not required to sign the consent document, provide a copy of the most current consent document being used.

SUMMARY OF THE RESEARCH

10. Have there been any adverse events, unexpected or unanticipated study-related problems which have not previously been reported to HSIRB? If **yes**, provide details on an attached sheet. ☐ Yes ☒ No
11. Is there new risk or benefit information not previously reported to the IRB? ☐ Yes ☒ No
 If **yes**, attach a memo indicating the risk or benefit information.
12. Summarize progress of the research using non-technical language that can be easily understood by a reviewer outside the discipline. Please use complete sentences to briefly summarize the research since the last review (initial or continuing). **Data collection is complete and analyses are in process.**
13. List and describe any complaints about the research study since the last HSIRB review (initial or continuing review); include action taken to resolve the complaints (If not applicable, type NA). **NA**
14. List any voluntary withdrawals by participants from the study since the last HSIRB review (initial or continuing review); include action taken as a result of the withdrawals. (If not applicable, type NA). **NA**

HSIRB Project Number: 13-03-32

SUBJECTS' CRITICISM

15. Have research subjects been enrolled (or subject records, specimens, etc. obtained)? ☒ Yes ☐ No
Provide a letter of explanation if no research subjects have been enrolled (or subject records, specimens, etc. obtained).
16. Total number of subjects approved in original protocol: 30
17. Total number of subjects enrolled so far: 30
If applicable: Number of subjects in experimental group: Number in control group:
18. Estimated number of subjects yet to be enrolled: 0

Please remember to include a clean original of the consent documents to receive a renewed approval stamp.

INVESTIGATOR'S ASSURANCE

I certify that the information contained in this HSIRB Application for Continuing Review and all attachments are true and correct. I certify that the research has been and will continue to be conducted according to the protocol as approved by Human Subjects Institutional Review Board. I agree that I will not implement any changes in the protocol until such changes have been reviewed and approved by HSIRB. If, during the course of the research, unanticipated risks or harm to subjects are discovered, I will report them to HSIRB immediately. I agree to follow all applicable federal regulations, guidance, state and local laws, and university policies related to the protection of human subjects in research, as well as professional practice standards and generally accepted good research practices for investigators

If this is a FINAL REPORT you may return the form electronically (signature is not required).

Edward A. Roth
Principal Investigator/Faculty Advisor Signature

4/15/14
Date

Rebecca J. Bumpner
Co-Principal or Student Investigator Signature

4/15/14
Date

Co-Principal or Student Investigator Signature

Date

Approved for a one-year extension by the HSIRB:

Amir Naugle
HSIRB Chair Signature

4/21/14
Date

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