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The Effects of Plainchant on Subjective Measures of Emotion and Heart Rate Variance

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An Honors Thesis by Alexander Twohy

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INTRODUCTION

Statement of Intent

Music therapy is an important tool used to aid in natural recovery from illnesses both physiological and psychological in nature. Many different aspects of music can be used to achieve this, with concrete elements of the music, such as tempo and mode, playing a role in its effectiveness, as well as more subjective elements, such as familiarity and musical experience, also contributing to the effect. Plainchant has recently been explored as a useful musical stimulus for the purposes of music therapy. It is characterized by calm, flowing melody, and a distinct lack of harsh dissonance. One monastic tradition (the one practiced by the monks of the Solesmes abbey in France) of plainchant uses a free flowing, less structured rhythmic style.

Sister Ruth Stanley (OSB) has recently used plainchant as a successful treatment tool for elderly hospice patients in terms of music therapy. In clinical practice, she has observed that patients listening to 10-15 minutes of plainchant two to three times a day chant have experienced an increase in heart rate variability (a measure of relaxation). She has also found that listening to chant "produces benefits to those with chronic illness by improving coping skills, quality of life, and overall sense of well-being." Stanley's argument for the reason chant is so effective is that the structure and melodious nature of chant elicits an inherent healing response from the body (Stanley, 2013).

However, plainchant has not been explored in the scientific literature in terms of empirical evidence with regards to its effectiveness as a music therapy tool. My thesis is designed to give evidence as to whether or not chant would be a universally effective music therapy stimulus by way of an exploratory study. To do this, I will measure responses to chant in two ways: physiologically and subjectively. My physiological measure will be heart rate variance, which measures the time distance between heart beats. When these distances become more erratic and farther apart, there is evidence of the activation of the parasympathetic nervous system, which is responsible for relaxing and healing the body. For the subjective measure, I will gauge how chant is reacted to in terms of self-reported emotional responses.

Because plainchant does not have standardized data in the literature, I will be actively comparing it to four music pieces which have been tested to elicit one of four emotional responses based on the two-factor valence/arousal model of emotion. This model divides emotion into two factors: valence, which is a measure of positive or negative reaction, and arousal, which is a measure of excited, energetic feelings (or lack thereof). I will then compare chant to these four conditions to determine which one it most resembles. These measures will give support as to whether or not chant would be an effective tool for music therapy. First, however, music should be established as having powerful effects on the human body.

A brief history of plainchant

Plainchant in the Catholic Church grew out of the musical traditions of the Jewish faith. It grew from a tradition in which the various parts of the Christian liturgy were sung rather than spoken, originally occurring in Jerusalem and the surrounding areas. This was later moved to the western church (Rome) by Damasus I around 370 C.E. For about five hundred years, chant became diversified among the various regions around western Europe, the area in which Christianity was primarily taking root. An offshoot of western chant was developed by the Eastern Orthodox Church and was known as Byzantine Chant. These chants were divided into eight modes, or echoi. These echoi became the basis for the eight church modes of the western church.

There is little historical record between this time and 590 C.E. However, several documents appear attributing the musical chants of the time to Pope Gregory I (Hence the name of Gregorian Chant). Recent scholars have begun to question this accreditation, however, and have since started using the term plainchant.

Around the year 750 C.E., France began to make stronger ties with the Catholic Church. Pepin the Short (r. 751-768 C.E.), the king of France at the time, sought to unify his kingdom through imposing a uniform body of music. His son, Charlemagne, who expanded the kingdom and later became the head of the Holy Roman Empire, promulgated the unity of church music started by his father. This caused chant to be spread throughout the empire, and due to the lack of communication and solidarity the way chant was performed, resulted in even more diversity in the chant.

As the centuries progressed, chant became more and more diversified. It had originally started as monophonic melody, but grew and evolved to include more polyphony. Beginning in the thirteenth century, established chant melodies began to be incorporated into larger, more secular work (the base-chant melody was referred to as cantus firmi). However, it was later refined and revised in the late 19th century by the monks of the Solesmes Abbey in France. They researched the original chants and styles used around 1000 C.E. and returned plainchant to its original monophonic sound. (Apel, 1990; Burkholder, Grout, Palisca, 2009).

Music has a definitive impact on the physical body

The physiological and emotional effect of music on the individual as well as its impact on mood has been extensively studied by the scientific community. Music's effect on the body has been studied in many diverse ways. One study focused on neurotransmitter levels (Gerra 1998) in which high-intensity techno music was associated with higher cortisol (a stress hormone), adrenocorticotropic hormone (a hormone that produces cortisol), and norepinephrine (an important activator of the flight or fight response). Another focused on the cardiovascular system (Bernardi, 2009), and found that cardiovascular responses can mirror musical energy levels and other components of music. Yet another explored respiratory responses (Etzel, 2005) where breath length and total lung exhalation were reduced when listening to sad pieces. Another study explored skin conductance levels (Zwaag, 2011). It was found that high stress pieces increased skin conductance levels (the amount of sweat on the skin).

One of the most utile applications of this research is music therapy. The theory of music therapy relies on the ability of music to relax and calm the patient, thus reducing stress and promoting natural recovery after trauma. Several studies have been conducted to gauge this phenomenon clinically. One study gauged stroke recovery time after listening to music (Sarkamo, 2010). It was found that music therapy increased stroke recovery after a six month music therapy regimen. Another measured anxiety and pain levels in patients prior to and after spinal surgery (Lin, 2011) and found that music therapy successfully reduced anxiety and pain in the patients undergoing surgery. Yet another explored the treatment of post-traumatic stress disorder (Carr, 2012) which found music therapy to be successful in treating PTSD when traditional measures had failed. A different study explored stress reduction in the hospice care setting (Nakayama, 2009), which found significantly lower cortisol levels in terminal cancer patients who were exposed to a 40-minute music session.

Music therapy promotes healing

Music therapy is a complicated process that is not yet completely understood. This study will look at its ability to invoke a calming, relaxed state in the body which results in a greater capacity for healing itself. This process relies on the idea of the immune system working more effectively when it is in a calm, relaxed state, as opposed to a nervous, agitated state (such as the anxiety some people feel in the hospital setting). One way of achieving this state is through the induction of positive valence. A study performed by Frederickson, et al. (2000) showed that films that produced emotions of contentment produced faster heart rate recovery in participants that had been exposed to an anxiety-producing stimulus. This was opposed by films that induced a sad or neutral state, which did not elicit the same recovery response. Heart rate recovery was gauged by taking several measures relating to the heart, including heart rate, finger pulse amplitude (which is a measure of vasoconstriction), blood pressure, and other measures. This is relevant because one of the goals of music therapy is to induce positive emotion, and this study shows that positive emotion helps induce heart rate recovery, and therefore lowers stress.

Another factor is the reduction of arousal. Arousal is defined as the overall physical responsiveness of the body (the amount of adrenaline being added to the blood stream, pupil dilation, heart rate increase, other signs that the sympathetic nervous system has been activated, etc.). When a low state of arousal is achieved, it is easier for the body to recover from injury. Bernardi et al (2009) found that slow, meditative music could reduce physiological measures of stress in the body, thus relaxing their participants. If music can achieve this calm, relaxed state, it can aid in the overall healing process.

Documented experiments of music impacting recovery

Since music therapy has been around for quite some time, there are several studies that have charted the use of music therapy while monitoring the progress of patients recovering from illness. One study found that patients who were recovering from a stroke, when exposed to daily music for a six month period, showed greater auditory sensory memory than those who just received regular rehabilitation. This is important, because this measure “has been shown to correlate with behavioral performance on tasks of working memory, verbal learning, and executive performance in schizophrenia, alcoholism, multiple sclerosis, speech production and comprehension in children, and in aphasiac patients” (Sarkamo 2010). Another study looked at patients who received music therapy when recovering from spinal surgery. Lin, et al. (2011) found that patients who received a significant amount of music therapy scored lower on physiological measures of stress than those in the control group. Again, the reduction of stress has been shown to aid in the recovery process. Another study looked at the effects of music therapy for patients recovering from post-traumatic stress disorder. Carr, et al. found that patients exposed to music therapy experienced a “significant reduction in the severity of their PTSD symptoms” along with a “marginally significant reduction in depression” compared with the control group (Carr et al, 2012). Yet another study showed that exposure to music therapy reduced the amount of stress in a hospice setting. Nakayama, et al. (2009) found that, when exposing terminal cancer patients in a hospice setting to music therapy, cortisol levels along with subjective measures of depression and anxiety were observed to significantly decrease, while subjective measures of refreshment increased significantly. Clearly, this is a well-documented and viable method of facilitated recovery.

Specifics of how music therapy relaxes people

Again, the tenet of music therapy relies on its ability to reduce stress and anxiety and induce calm, relaxing emotional states. It has been postulated that certain aspects of the music have impacts on these relaxing qualities. A study by Zwaag, et al. (2011) found that the aspects of tempo, mode[1], and percussiveness all have influences on emotional states (fast tempi, major modes, and high percussiveness all influenced positive emotions while their inverses influenced negative emotions). Gomez and Danuser supported this research with their own findings of mode, harmonic complexity, and rhythmic articulation corresponding to positive and negative valence. Tempo, accentuation, and rhythmic articulation were best correlated with arousal.

The traits of individual listeners may also have an impact on musical influences. Gender has been correlated with increased responsiveness to arousing and unpleasant stimulus in terms of physiological responses except for cortisol levels (Nater 2006). It was found that women were more likely to react negatively to aversive stimuli. It also has been found that extensive musical experience has been correlated to an increased negative response to dissonance (Dellacherie 2010). This means that musicianship makes a difference as to just how negatively a person reacts to dissonance (the more musicianship present, the harsher the reaction). These studies reveal that there are several nuanced factors that can influence an individual's response to music therapy that make studying its overall effects rather complicated.

Examples of different kinds of music used

Many different kinds of music have been tested to exploit these characteristics. Since the effectiveness of the music therapy varies depending on the music structure, many different pieces

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[1] Mode refers to the nature of the scale used to construct the tonal center of a piece of music. The mode is determined by the successive difference between pitches in the scale, which are either semi-tones or whole tones. The two most common modes are the major and minor mode but there are actually eight modes that have been used throughout history. Plainchant utilizes all eight modes.

in different genres have been examined. Common practice music is the predominate genre, but others appear with some frequency, including Renaissance music (Nater, 2006), pop music (Burns, 1999), and film music (Eerola, 2011). However, upon an extensive review of the literature, I found no study that had attempted to test plainchant in an experimental setting. Chant, which is characterized by soft accentuation, calm, flowing tempos, and primarily diatonic nature, appears to be, on the surface, an excellent candidate for music therapy. In fact, clinical evidence does exist for the use of chant in a musical setting (Stanley, 2013). However, no empirical evidence exists for this genre.

Establishment of HRV as a way of measuring music therapy value

If chant is to be considered for a potential music therapy stimulus, it needs to be tested for effectiveness. One way to do this is to analyze its effect on the heart. Now, the majority of heart measurement is taken by heart rate, over the average beats the heart makes over any given minute. Heart rate variance, on the other hand, is a measure of the time between heart beats. It is a powerful measure of the interplay between the sympathetic and parasympathetic aspects of the autonomic nervous system (The sympathetic nervous system [SNS] is responsible for activating the body to respond to dangerous, high threat-level situations, and is also known as the flight or fight response. The parasympathetic nervous system [PNS] is responsible for the repair of the body, the activation of growth in cells, and the maintenance of the rate of nutrient acquisition through digestion, also known as the rest and digest response). When the SNS is activated, overall heart rate increases, which causes the distance between beats to diminish. Conversely, when the PNS is activated, the heart experiences deceleration of beat, and the distance between beats becomes farther apart.

Another way to look at HRV is the frequency of activation signals being sent to the heart. Heart beats are generated by electrical signals that are generated by the sinoatrial node, which is located inside the heart. Signals can be either high or low in nature.   Low frequency signals are indicative of SNS activation, while high frequency signals are signs of PNS activation. It is important to note that the activation of the SNS is a sign of high levels of stress, while the activation of the PNS is a sign of a reduction or lower level of stress. The more effective a stimulus is at increasing activation of the PNS, the more effective it is at being an effective therapy.

While still not an overly-common measure, HRV has been used to explore the effects of music on the human body. Iwanaga, et al. (2005) explored the effects of music on HRV with three conditions: sedative music, exciting music, and no music. They found that both low-frequency signals and the low-frequency/high-frequency ratio increased during all musical conditions, but not for the no music condition. However, there was a significantly higher high-frequency component on the sedative music, while the exciting music and the no music conditions had the same high-frequency values. This high frequency component suggested that sedative music might play a role in activating the PNS.

Establishment of emotion as way to measure music therapy value

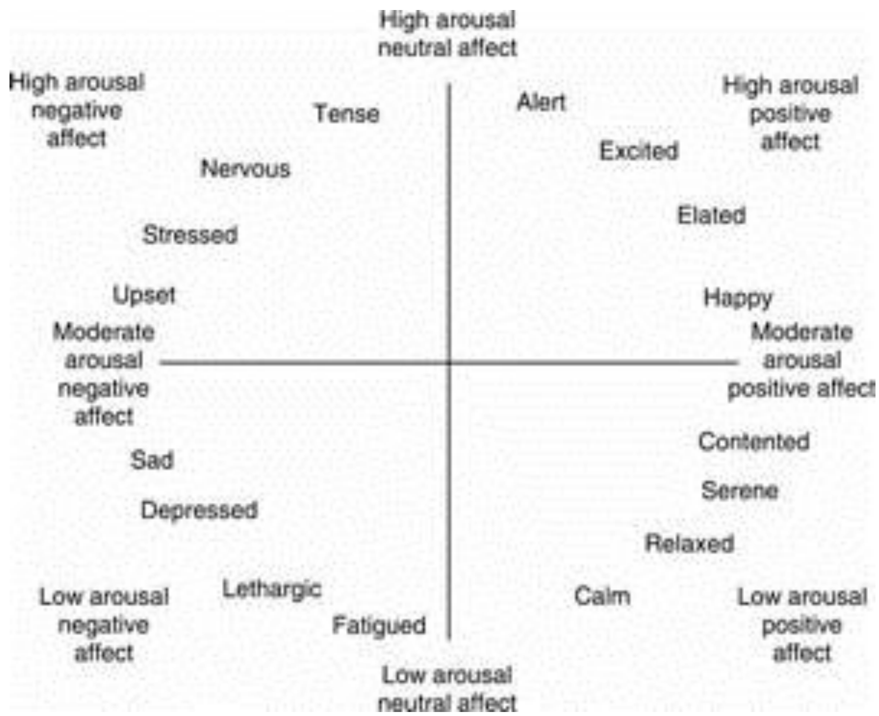

Figure 1: Model of valence and arousal[2]

Another way to evaluate music therapy potential is to measure its impact on emotion. As detailed above, the emotional state of an individual has an impact on recovery from illness. One way to look at this is through the dual concept of emotion, as first presented by Russel in 1980. Emotions can be classified by two traits: valence and arousal. Valence is a measure of positive or negative emotion (happiness versus sadness, excitement versus fear, serenity versus depression, etc.). Arousal is a measure of the energy level of the emotion (calm versus excited, morose versus terrified, etc.). In Figure 1, it can be seen that many emotions can be charted using this two-factor model. As detailed above, it has been shown that positive valence-inducing stimuli have an effect on the reduction of stress, and low arousal, or calming stimuli also have an effect

[2] Picture Credit: http://mat.ucsb.edu/~ivana/200a/background.htm

on the reduction of stress. One study found that high-valence, low-arousal music helped participants recover from an acute stressor faster than other kinds of music in terms of skin conductance level and heart rate recovery (Sandstrom et al 2010). Therefore, an ideal music therapy stimulus would be one that induced levels of high valence and low arousal.

Musicians respond differently

However, not everyone responds physiologically to music in the same way. It has been shown that musicians tend to have different physiological responses to music than do people without a musical background. One study by Dellacherie, et al. (2011) showed that people who had at least three years of musical training had stronger subjective and physiological reactions to dissonance than people without training did. Another study by Bernardi, et al. (2009) showed that while musicians and non-musicians had similar subjective responses to music, musicians tended to have faster cardiovascular responses and more respiratory modulation in response to music stimuli than did non-musicians. Therefore, any study trying to determine the effectiveness of music therapy should control for musical background and training.

Explanation of current study

The purpose of this study is to gather subjective and physiological measures of emotion for Plainchant on an empirical level. Four musical excerpts were chosen as control conditions (one corresponding to each possible valence/arousal combination) and were presented along with the test condition of plainchant to help determine where on the axis of valence/arousal chant would fall. Physiological measures were also taken for all five conditions along with baseline measures. It was hypothesized that chant would induce positive valence and low arousal, along with increased heart rate variability.

EXPERIMENTAL

Participants

Participants were undergraduate college students recruited from two different sources. The first was a psychology of perception course, and the second was a history of women in music course. These two groups were selected in an attempt to give an even split between musicians and non-musicians. Participants were offered extra credit in their respective courses as incentive for participating in the study. There were 11 males and 21 females who participated in the study. There were 25 sets of complete data for physiological measures and 29 sets of subjective emotional responses due to error in computer processing. Informed consent was granted from each subject and the project received permission from the College of Saint Benedict/Saint John's University Internal Review Board.

Stimuli

This study used the same four musical stimuli that were used by Sandstrom. et al, (2010) to conduct a similar study on valance/arousal and physiological interactions to music. Each piece was keyed to a particular target emotion, which had been identified in a previous study as relating to one of the four possible valence/arousal combinations (happy for high arousal/high valence, serene for low arousal/high valence, sad for low arousal/low valence, and agitated for low arousal/high valence)(Nyklicek et al, 1997; Sandstrom 2010). The pieces selected were Johann Strauss' "Unter Donner und Blitz (Thunder and Lightning) polka"[3] (happy), Georges

[3] New Symphony Orchestra of London, Alexander Gibson. (n.d.). Strauss : Unter Donner und Blitz, Polka, Op. 324 [CD]. Astorg Classical.

Bizet's "Intermezzo" from the Carmen Suite[4] (peaceful), Edvard Grieg's "Aase's Death" from the Peer Gynt Suite[5] (sad), and the adagio from Dmitri Shostakovich's 8th Symphony[6] (agitated). The piece of chant selected was Alleluia Justus Germinabit (1), LU 1192 by Choeur des Moines de L' Abbaye de Saint-Pierre de Solesmes[7].

The Strauss excerpt has a driving tempo, is in the major mode, is quite percussive, and has the general feel of a march. The excerpt has, in general, two areas with regard to melodic style. One is a softer, string based timbre that has flowing melodies while maintaining the quick, fast paced nature of the work. The second is a more prominent brass theme, that while louder and more brash then the string area, still contains the light hearted, soaring nature of the first area. Both sections are interspaced with cymbal crashes that add a sense of both forward motion and comedy to the piece. The high energy of the piece along with the lack of extreme dissonances firmly places it in the high valence/high arousal category. This classification is supported by Zwagg, et al., who found that fast tempo led to higher arousal and higher valence (especially during a fast percussive piece).

The Bizet is characterized by a solo flute with a slight string accompaniment, with a few other woodwinds added later on. It has a much more reserved tempo and very low levels of dissonance (being primarily in the major mode) while being overall a quieter work. These characteristics place it in the category of high valence, low arousal. This is also seen Zwaag, et al., as minor mode pieces tend to evoke higher levels of arousal then major mode selections.

[4] Carmen Suite No. 1: III. Intermezzo. (2013). On Valentine's Day – 50 Classical Love Songs [CD]. Hungarian National Philharmonic and Emil Edlinger;

[5] Peer Gynt Suite No. 1, Op. 46: II. Aase's Death (Andante doloroso) [Recorded by S.]. (2010). On The 99 Darkest Pieces of Classical Music [CD]. Slovak Philharmonic Orchestra;.

[6] Symphony No.8 In C Minor, Op.65 - 1. Adagio [Recorded by C.]. (1989). On Shostakovich: Symphony No.8 [CD]. Decca Music Group.

[7] Alleluia Justus Germinabit (1), LU 1192. (2011). On Chants Grégoriens [CD]. Choeur des Moines de L' Abbaye de Saint-Pierre de Solesmes, Dom Jospeh Gajard.

The Grieg is also characterized by slow tempo and an overall quieter sound, but is also primarily in the minor mode, along with more dissonance. Its sound is primarily in the strings, with some winds in the background. These traits place it in the low arousal and low valence category. The slow tempo in particular contributes to its low arousal, along with the minor mode being evocative of low valence (Gomez and Danuser , 2007).

The Shostakovich is a much more dissonant, grating work. It is moderately fast, marked with moderate percussiveness, as well as harsh dissonance in the minor mode, as well as an intense, loud sound. The instrumentation is quite thick, relying on the entire modern orchestra, with a particular emphasis on the brass. These characteristics place it firmly in the low valence/high arousal category. The sound intensity matches Gomez and Danuser's findings that high sound intensity is linked to low valence/high arousal pieces, while the moderately fast tempo contributes to the high arousal nature (Zwaag et al 2011).

The plainchant is marked by softer sound intensity, along with a lack of dissonance, as well as being monophonic. The quality of the sound is much softer as well as having less dynamic variation than most of the other pieces since it only contains voice (specifically low pitched voice and traditionally it is only sung by men). The tempo is also moderately slow. However, the style used in this particular chant tradition lacks a well-defined meter, which causes it to be more freeform and flowing than be restrained by a strict meter. It predicted these traits would place it in the high valence/low arousal category. This prediction is supported by slow tempos are associated with lower arousal (Zwaag et al, 2011), along with the consonance evoking a more positive valence response (Dellacherie et al, 2011). This piece was selected after reflection on Stanley's 2013 work in which she recommends that chant used for the purpose of music therapy be in mode one (Dorian). The Dorian scale is the same as a natural minor scale with the exception of the sixth scale degree raised a semi-tone.

The recording was cleaned using the Audacity audio editing software. The duration for each piece was two minutes and 30 seconds. This time length was chosen due to similar lengths in other studies (Sandstrom et al, 2010, Zwaag et al 2011) Once again, each piece was cut to this length using the Audacity music editing software. This time was selected by comparing Sandstrom, et al's times for their experiments and also comparing to the times done in other studies.

Procedure

Participants were requested to report to the laboratory with no prior instruction. A consent form was first presented to the participants. After that was signed, the experimenter briefed the participants on the procedure. The participants were informed that they would be reacting subjectively and physiologically to 5 musical excerpts, and would be asked to rate the pieces in terms of their reaction to them on scales of happiness, sadness, agitation, and serenity (they were informed that serene meant a calm, relaxed state)(APPENDIX 1). They were then given the heart rate belt to wear, and were instructed that the belt needed to be located under the clothing, around the abdomen so that the silver contact points were touching the skin. The participants donned the belt, and the experimenter confirmed verbally that the belt was located in the correct location. Next, the participants were taught how to use the accompanying watch. The watch records the data collected from belt wirelessly. Participants were asked to press start and stop buttons on the watch to create separate files for the different musical stimuli. Participants were then asked to repeat how to work the watch back to the experimenter. The remainder of the procedure was explained by informing the participants that the computer display would guide them through the remainder of the procedure. They were then instructed to rest quietly for five minutes while baseline data were recorded. Participants also filled out the music background survey during this time (APPENDIX 2). After five minutes were up, participants were prompted to press a key to start the first musical sample. The musical samples were presented in a randomized sequence to partially counterbalance ordering effects. At the end of each sample, a brief survey was given asking the participant to rate if the following piece made them feel each of the four target emotions (happiness, sadness, agitation, and serenity)on a seven point Likert scale (1 being strongly disagree, 7 being strongly agree, and single intergers 1-6 in between) on each of the four target emotions (happiness, sadness, agitation, and serenity). After each emotion survey, a period of five minutes of silence was built in to prevent possible carry over effects. The subjects were then asked to remove the belt and watch and were debriefed.

Derivation of measures

The heart rate data was later reduced into RMSSD and HF/LF ratio by (Polar product software here). RMSSD, or the root mean square of successive differences, in a reduction of the measure of the difference between heart beats. A larger value in RMSSD would mean that HRV is increasing, and the PNS is being activated, and thus a greater state of relaxation. A lower value in RMSSD would mean that HRV is decreasing, and the SNS is being activated, and this a greater state of agitation The HF/LF ratio, or the High Frequency/Low Frequency Ratio, is the measure of high frequency waves sent to the heart versus low frequency waves sent to the heart. A higher HF/LF ratio is indicative of the PNS being activated, and thus a greater sense of relaxation, while a smaller HF/LF ratio is indicative of the SNS being activated, and thus a greater sense of agitation.

Equipment used

This study utilized the Polar RS800CX Sports Watch with accompanying heart rate monitor belt, Polar ProTrainer 5 analysis software, and the Emmanuel College Music Background Questionnaire (Zhao, X., Mauer, M.V., & Doyle-Smith, N. C., 2012).

RESULTS

Results have been separated into three categories: self-reported emotional data of the four controls and the Plainchant, physiological data of the four controls and the Plainchant, and the correlations of musical background with physiological measures and self-reported emotional measures. Again, each of the four standard pieces was linked to one of the four possible valence/arousal combinations: Strauss' "Unter Donner und Blitz" (Thunder and Lightning) polka (high-valence, high-arousal), Bizet's "Intermezzo" from the Carmen Suite (high-valence, low-arousal), Grieg's "Aase's Death" from the Peer Gynt Suite (low-valence, low-arousal), and the adagio from Shostakovich's 8th Symphony (low-valence, high-arousal). Subsequently, the high-valence, high-arousal condition will be referred to as "Strauss", the high-valence, low-arousal condition as "Bizet", the low-valence, low-arousal condition as "Grieg" and the low-valence, high-arousal condition as "Shostakovich".

Self-Reported ratings

The four self-reported ratings were analyzed using a repeated measures 2x2 ANOVA (analysis of variance). The ANOVA measures the differences between the means of the individual groups. Each emotional subject word was compared to the other three emotional subject words in terms of how valence contributed to the scores, how arousal contributed to the scores, and how valence and arousal worked together to affect the scores.

For the self-reported state of agitation, there was a significant main effect for arousal (F(1,29)=103.6, p<.001, η^2 = .781), which revealed that high-arousal pieces were rated more agitating than low-valence pieces. There was also a significant main effect for valence (F(1,29)=33.96, p<.001, η^2=.539). This revealed that low-valence pieces were rated more agitating then high-valence pieces. Also, there was a significant arousal by valence interaction (F(1,29)=16.133, p=.001, η^2 = .319). This revealed that if a piece was both low-valence and high-arousal, it was rated even higher on agitation then would be expected if the high-valence/high-arousal effects were simply added. This can be seen in Figure 2, which shows that the high-arousal/low valence piece scored significantly higher than the other three pieces.

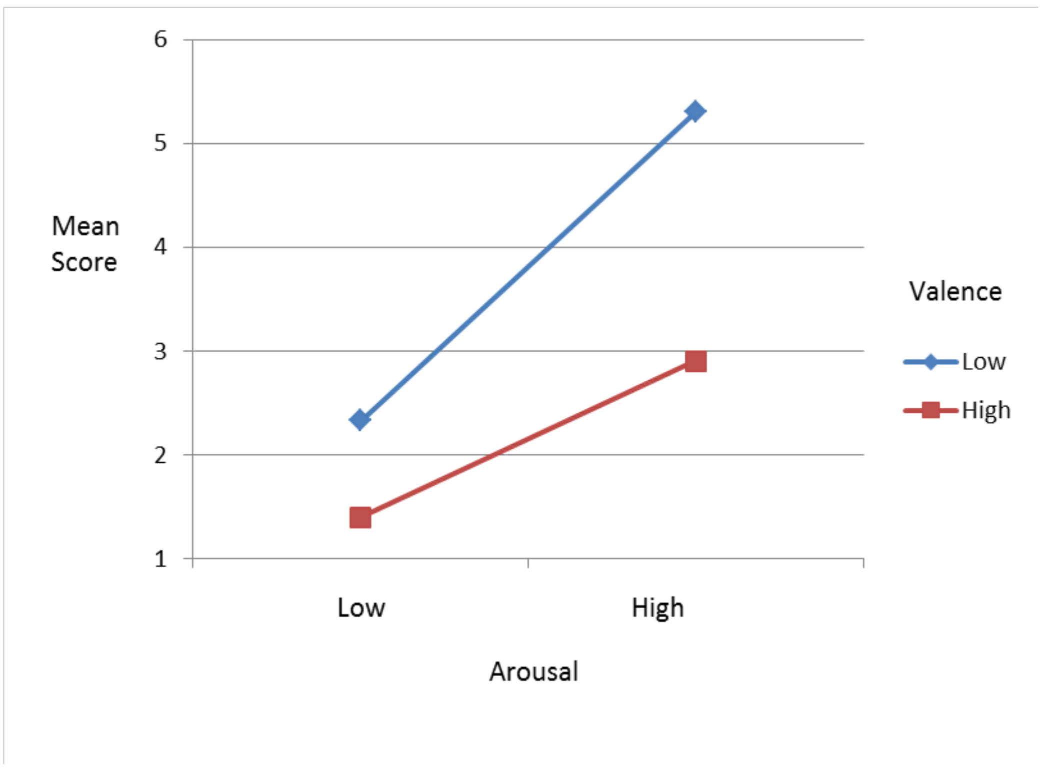

Figure 2: Subjective scores of agitation: mean values

For the self-reported state of happiness, valence was the only significant main effect (F(1,29)=96.32, p<.01, η^2 = .769) which reveals that only high-valence pieces were rated more happiness-invoking than low-valence pieces. The effect of arousal approached significance

($F(1,29)=3.577$, $p=.07$, $\eta^2 = .110$) which means that high-arousal pieces may have been reported as more happiness inducing than low-happiness pieces, but this difference could be due to error. This can be seen in Figure 3, as the high-valence pieces are clearly rated as happier than low-valence pieces. There is a small amount of difference between high and low arousal pieces, but this difference could be due to statistical error.

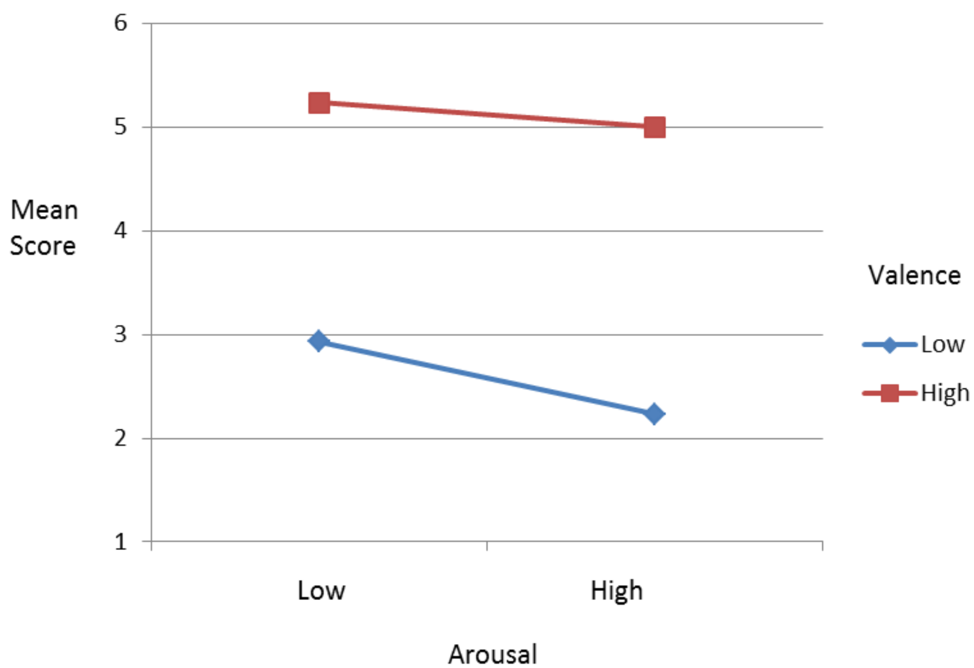

Figure 3: Subjective scores of happiness: mean values

For the self-reported state of sadness, there was a significant main effect for arousal ($F(1,29)=46.875$, $p<.01$, $\eta^2 = .547$) which revealed that low-arousal pieces were rated more sad than high-arousal pieces. Also, there was a significant main effect for valence ($F(1,29)=53.1$, $p<.01$, $\eta^2 = .647$) which means that low-valence pieces were rated more sad than high-valence pieces, which was expected. Combining low-arousal and low-valence pieces also produced a higher sadness rating than simply combining the effects for low-arousal and low-valence, which can be seen in the significant arousal by valence interaction ($F(1,29)=18.836$, $p<.01$, $\eta^2 =.394$).

In Figure 4, this can be seen quite clearly by the low-arousal/low-valence piece scoring much higher on sadness than any other piece.

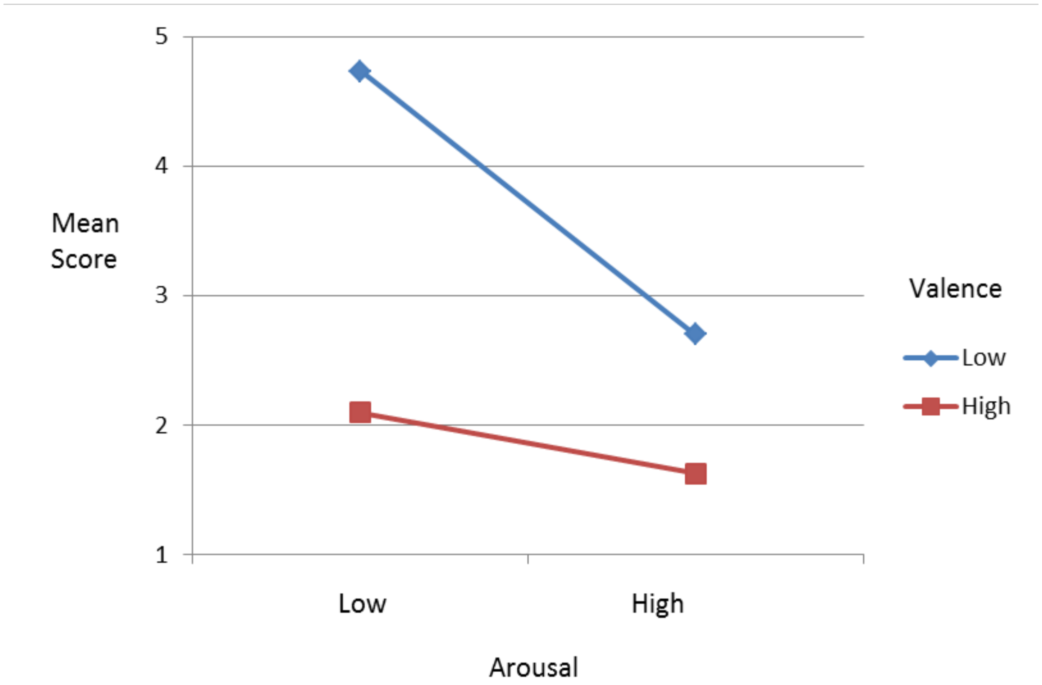

Figure 4: Subjective scores of sadness: mean values

For the self-reported state of serenity, there was a significant main effect for arousal ($F(1,29)=133.038$, $p<.01$, $\eta^2 = .821$) which means that low-arousal pieces were rated more serene then high-arousal pieces. High valence pieces were also rated higher in terms of serenity than low-valence pieces, which can be seen in the significant main effect for valence ($F(1,29)=20.659$, $p < .01$, $\eta^2 =.416$). When high-valence and low-arousal occurred in the same piece, the serenity rating was even higher than would be expected if the effects for high-valence and low-arousal had simply been combined, which is shown in the significant main effect for the arousal by valence interaction ($F(1,29)=4.492$, $p<.05$, $\eta^2 =.134$). This is seen in Figure 5, as the high-valence/low -arousal condition is much higher than any other piece.

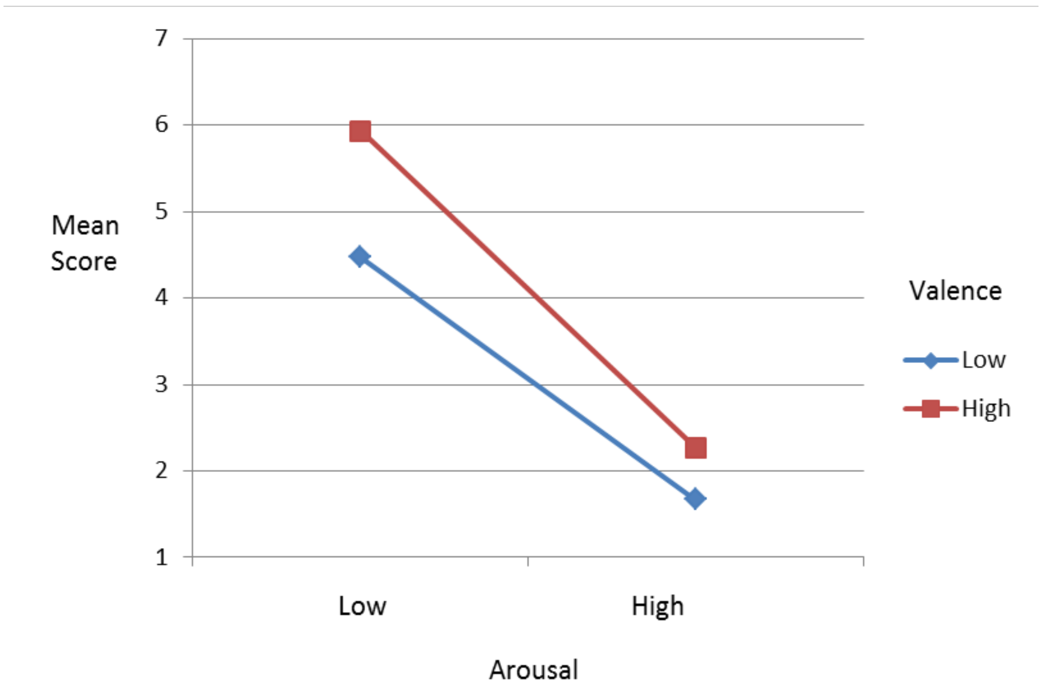

Figure 5: Subjective scores of serenity: mean values

These results are in line with what the literature would suggest. Each musical excerpts was ranked as highest in its respective emotion-invoking category. This is exactly what would be expected, with the only exception being that arousal did not play a role in happiness. Low-arousal was supposed to inhibit happiness, while high-arousal was supposed to elicit it.

In terms of post hoc analysis, a LSD (least significant difference) analysis was performed to check if the data were indeed different from one another. Each set of self-report data was compared to each other set of self-report data within the emotional comparisons (for example, Grieg was compared to each of the other samples to confirm that it was different from the sets). Plainchant is then compared to these samples to see how it relates to these normative conditions. Essentially, the means of the plainchant scores are compared against the other test conditions. If a score is not significantly different from another score, it means that the two conditions effectively evoked the same response.

In terms of agitated self-report data, all conditions differed from each other significantly except for Strauss and Grieg (this p value approached significance, .17), and Grieg and chant. Therefore, as can be seen in Figure 6, Shostakovitch was the highest rated in terms of agitation (following what should have happened), and all other stimuli were rated less agitating. Strauss and Grieg were close to being different, but this interpretation could be due to error. Chant and Grieg effectively elicted the same amount of agitation.

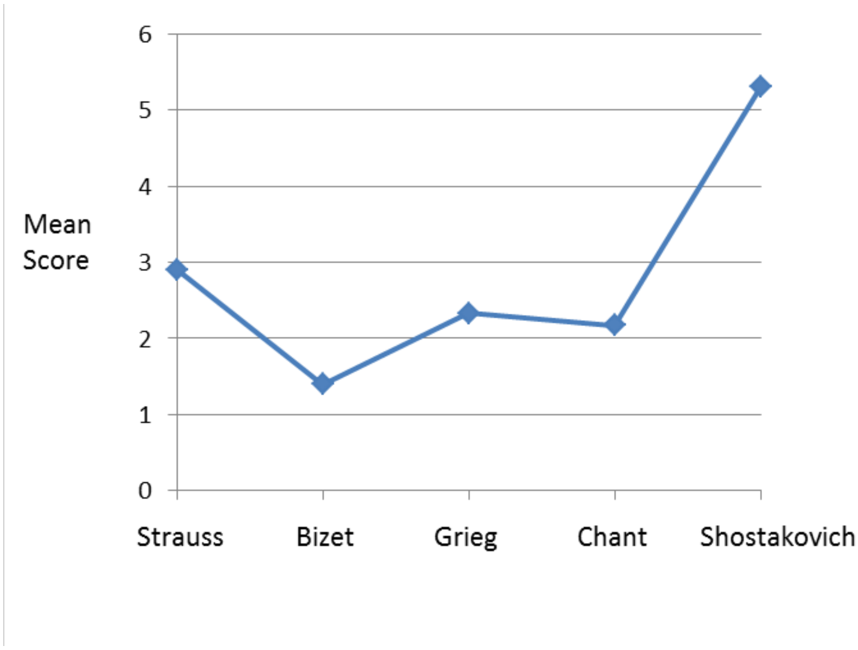

Figure 6: Mean scores of agitation with chant

In terms of happy self-report data, all conditions significantly differed from each other except Strauss and Bizet, Grieg and chant, and chant and Shostakovich (this set approached significance (p=.1). Therefore, as can be seen in Figure 7, Strauss and Bizet were effectively the highest rated in happiness (as expected), with Grieg, chant, and Shostakovitch having lower happiness ratings these last three were very close to each other, with chant and Grieg being statistically the same in terms of happiness and chant and Shostakovich being very close to the same statistically.

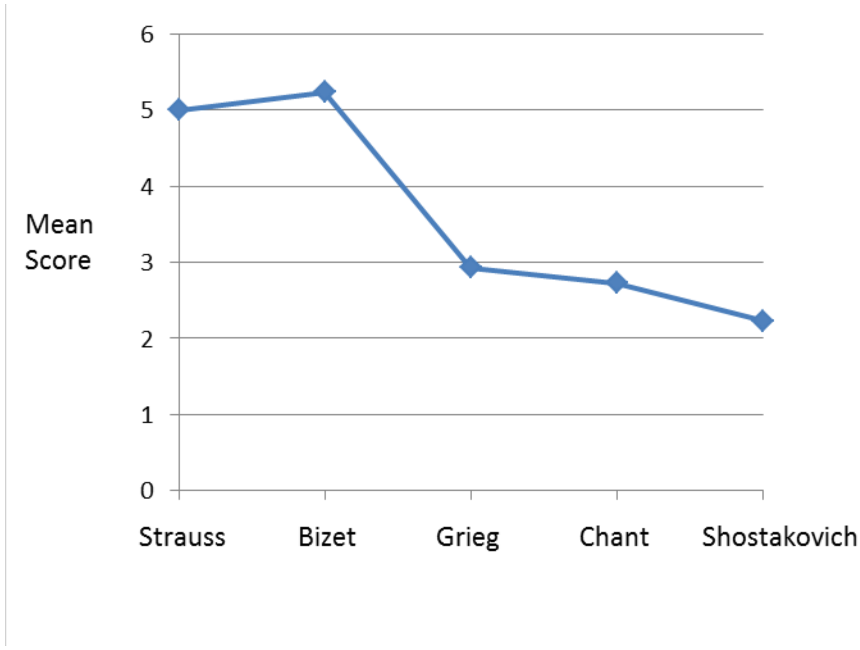

Figure 7: Mean scores of happiness with chant

In terms of sad self-report data, all conditions differed from each other significantly except for Bizet and Strauss (this approached significance, $p=.075$). Therefore, as can be seen in Figure 8, Grieg was clearly the highest, closely followed by chant. Bizet and Strauss evoked the lowest sadness ratings, and are statistically insignificant from each other.

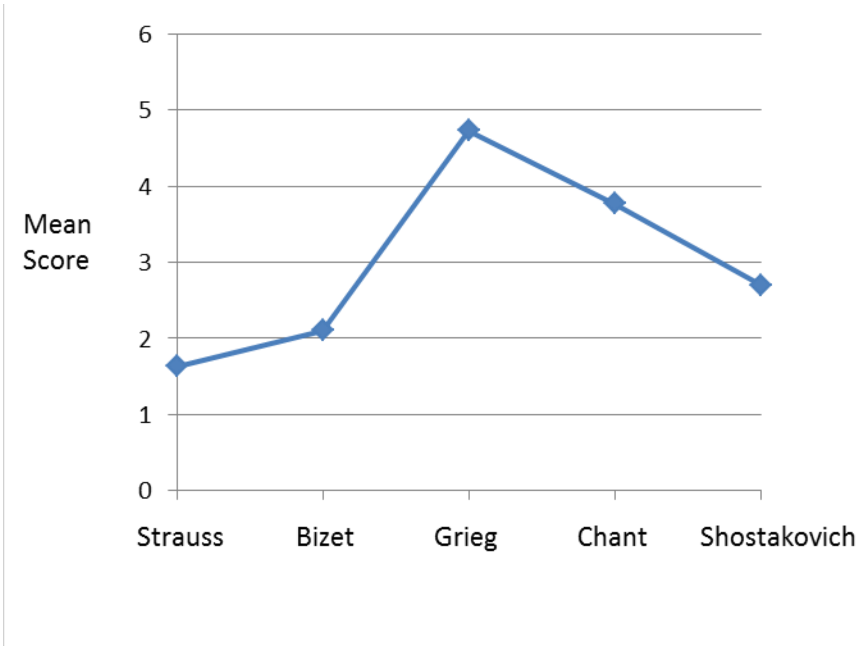

Figure 8: Mean scores of sadness with chant

In terms of serene self-report data, all conditions varied from each other except for Strauss and Shostakovich (this approached at p=.056) and Grieg and chant. As can be seen in Figure 9, Bizet is the highest rated in terms of serenity. Grieg and chant follow it, but are statistically indifferent from one another. Shostakovich and Strauss evoke the least amount of serenity (yet do still invoke some level of serenity), and are very close to being statistically the same.

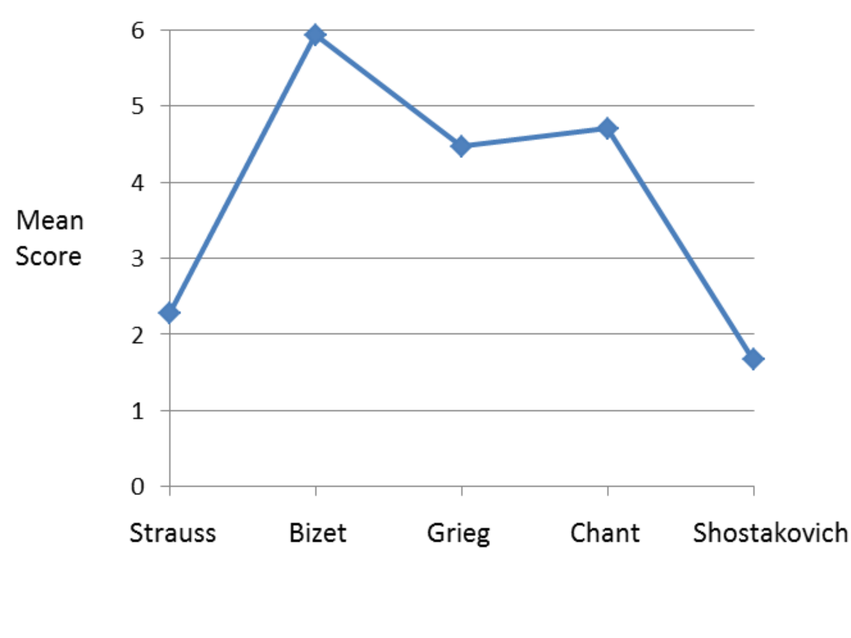

Figure 9: Mean scores of sadness with chant

These data suggest that, in terms of emotional self-report, chant evokes emotions most similar to Grieg, the low-arousal, low-valence condition. This is contrary to the beginning hypothesis that chant would follow Bizet (the low-arousal, high-valence condition).

Physiological data

To analyze physiological results, a single factor repeated measures ANOVA (analysis of variance, used to compare variations between means of groups) was performed on all five test conditions as well as the baseline data. In terms of heart rate, all test conditions elicited significantly lower heart rates than the baseline ($p < .05$) as can be seen in Figure 10. This means that for heart rate, there were no differences among the test conditions, only from the baseline. In terms of RMSSD, or root mean square of the successive differences (a way of statistically reducing the difference between heart beats), all conditions elicited significantly higher RMSSD than the baseline ($p < .01$) as can be seen in Figure 11. Also, for RMSSD, the only significant differences between conditions were that Strauss was significantly higher than Bizet. For

RMSSD, there were no differences between the test conditions except for Strauss and Bizet and all test conditions differed significantly from the baseline.

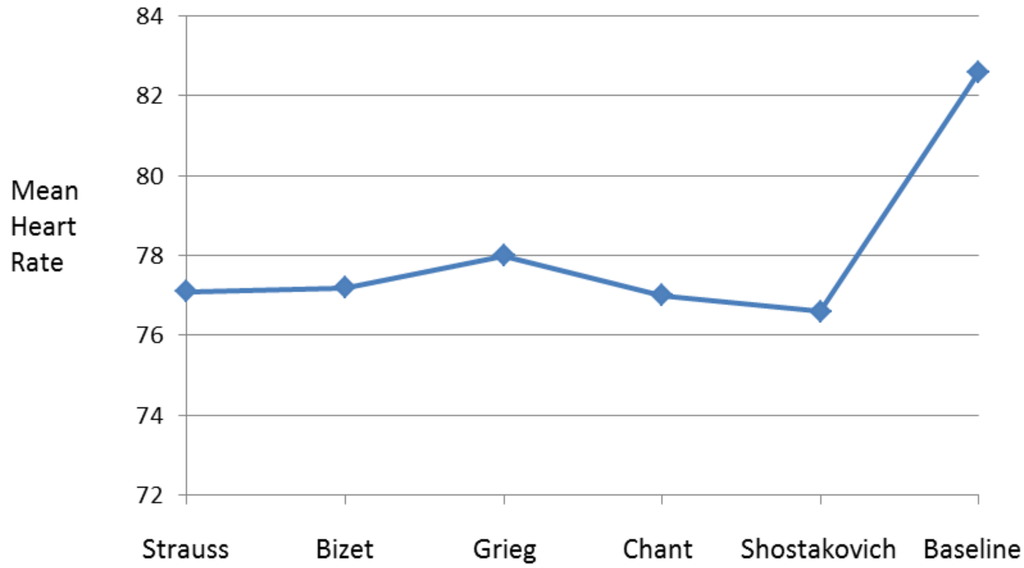

Figure 10: Mean heart rate

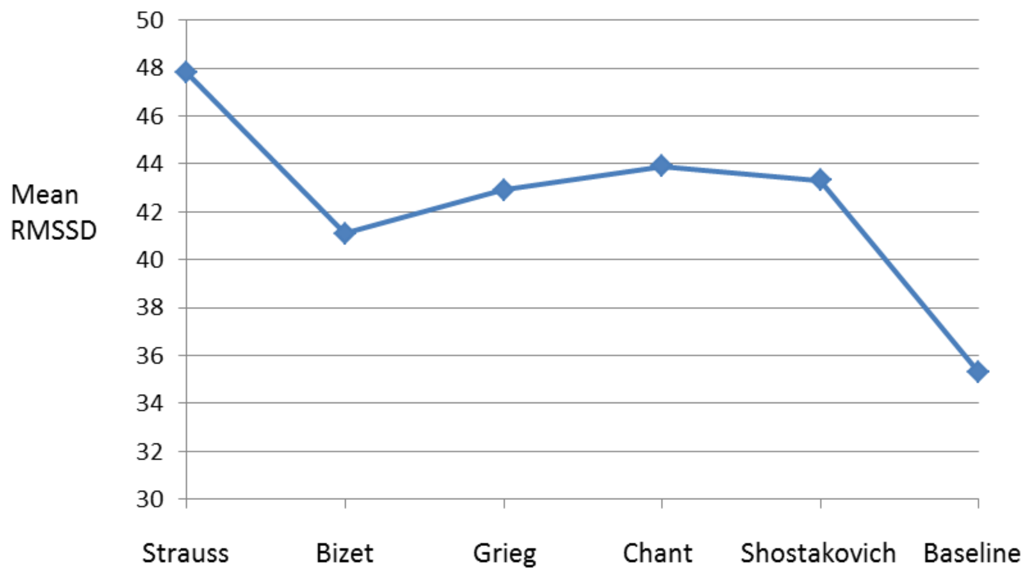

Figure 11: Mean RMSSD

Music Background data

Musical background data was collected from the Emmanuel College Music Background questionnaire. The two significant data results from the questionnaire were music training, which is the number of years the participant had received formal musical training, and active musicianship, which is the number of hours per week the participant actively participates in music.. These scores were correlated with self-report emotional data and physiological data using two-tailed bivariate correlations.

The range of scores of formal training was from 0 to 16 years (mean score 1.13 years) while the range of scores of active musicianship was from 0 to 13.5 hours (mean score 1.63 hours per week).

When correlated with self-reports of agitation, formal training was negatively correlated with agitated reports on Shostakovich ($p < .01$, $r = -.479$) and active musicianship was negatively correlated with agitated reports of Strauss ($p <.05$, $r = -.398$). This means that those with musical training were mildly less likely to rate Shostakovich as agitated and those that had more years of active musicianship were mildly less likely to rate Strauss as agitated.

When correlated with self-reports of happiness, active musicianship was correlated with happy reports of Strauss ($p < .05$, $r = .387$) and the correlation between self-reports of happiness of chant and active musicianship approached significance ($p = .074$, $r =.331$). Therefore, those that had more years of active musicianship were mildly more likely to rate Strauss as happy and it was almost significant that those with more years of active musicianship rated chant mildly more happy.

There were no correlations between self-report ratings of sadness and musical training or active musicianship.

When correlated with self-report measures of serenity, active musicianship was positively correlated with happy reports of Strauss ($p < .01$, $r = .508$). This means that those who had more years in active musicianship were more likely to report Strauss as serene.

When correlated with RMSSD, active musicianship was positively correlated with increased RMSSD of Grieg ($p < .05$, $r = .386$) and Shostakovich ($p < .05$, $r = .396$). Therefore, those that had more years of active musicianship were mildly more likely to have increased RMSSD when listening to Grieg or Shostakovich.

DISCUSSION

Restatement of purpose and hypothesis

The purpose of this study was to understand the effects of Plainchant on physiological and subjective factors of emotion. To do this, heart rate variability data along with subjective measures of valence and arousal were taken for Plainchant along with four other musical pieces standardized for the four quadrants of the valence/arousal spectrum.

Subjective measures

The results for subjective measures were somewhat in line with the literature. To begin, all four of the pieces that were standardized for the four quadrants of emotion were the highest rated on their individual target words. For example, Strauss, the piece targeted to evoke high arousal and high valence, did just that in the subjective responses. This held true for each of the four pieces, which is to be expected, since they were selected from published studies to elicit these responses (Sandstrom et al 2010, Nyklicek et al 1997).

The interesting result comes from the Plainchant. It was hypothesized that Plainchant, as a potential use for music therapy, would most closely follow Bizet (the piece targeted for low arousal/high valence) in terms of subjective ratings. However, it turns out that chant had most closely followed Grieg (the piece targeted for low arousal/low valence). The results revealed that chant would almost always follow Grieg when being compared to subjective data. Indeed, when looking at subjective results for Grieg's target emotion, sadness, chant was the second highest in terms of marginal means (see Figure 7). When looking at the measure chant was hypothesized to score high on (serenity), chant and Grieg were statistically the same (see Figure 8).

One way of interpreting this is that music familiarity might have something to do with valence reactions to chant. It is possible that few people have actually been exposed to sufficient amounts of chant to be comfortable with it, as it is almost exclusively used in the Catholic Church for monastic and liturgical ritual. One study showed that patients preparing for surgery who were allowed self-selected music to listen to had lower levels of stress before surgery than those that simply rested (Miluk-Kolasa 1996). Another study by Schubert (2007) found that enjoyment of music (valence) was strongly correlated with familiarity. So, it could be postulated that low valance scores for chant could be a result of lack of familiarity with the genre, which is likely due to its rareness.

Physiological measures

The results from the physiological measures (heart rate variability) had two important findings: the differences from baseline and musical conditions, and the greatest reduction of heart rate variability coming from the high-valence/high arousal condition.

Again, the first result was that all test conditions, including chant, produced significantly higher physiological readings from the baseline. More importantly, they were all significantly higher than the baseline, which means that all of the music conditions had a significant impact on raising RMSSD, which has been correlated with a more relaxed state and an activation of the parasympathetic nervous system. One interpretation is that it indeed was the music conditions that caused this change in RMSSD. In terms of the original hypothesis, this would support the idea that chant has potential use in music therapy since it had a comparable effect on the elevation of RMSSD. However, it is also possible that this may have been caused by simply resting. The baseline readings started immediately after the subject had been settled, and it is possible that the shift upward in RMSSD could be due to the participants simply resting quietly, which does have a documented impact on heart rate variance (Ellis et al, 2012). It is impossible to tell either way from the data, so either interpretation could be correct.

The second result is the high RMSSD level that was experienced by participants experiencing the Strauss condition (high arousal/high valence). Now, it is important to note that the Strauss condition only was significantly different from one other condition besides baseline, but this is still unusual. The literature suggests that low arousal/high valence will result in the greatest amount of HRV. The main interpretation I believe that should be taken here is that the value did not significantly differ from the other three highest levels of RMSSD (all conditions besides Bizet, or low arousal/low valence). This is likely due to the low power of the experiment due to such a small number of participants. Another explanation is that the music exposure time might have been too short (study).

Music background results

The correlations of music background data have some interesting results. Many of the significant correlations are found when the background data is correlated with the Strauss and Shostakovich conditions (High valence/High arousal and Low valence/high arousal respectively). These correlations suggest that the music background factors decrease the arousal ratings of these conditions. In other words, people with higher levels of music background are less likely to be aroused by high arousal conditions. This is interesting, and is supported in the literature that musicians react differently to musical stimuli then people without musical experience (Bernardi et al, 2009). Some studies show that the opposite effect should be expected, however. Dellacherie, et al. found that highly trained musicians were more sensitive to dissonances and reacted more strongly to them physiologically then those with low musical experience. This is interesting, as it also contradicts the active musicianship-RMMSD correlation with the Grieg and Shostakovich conditions, which were both mildly more likely to have raised RMSSD (again, a more relaxed state). Those correlations suggest that music experience is correlated with more relaxed states from low valence and a low valence/high arousal condition. One explanation for this is that Dellacherie measured responses over very short intervals (ten seconds), whereas this study used much longer exposure times.

Another result is the happiness self-report of chant and active musicianship correlation that approached significance. This result would support the idea that familiarity would increase valence, since musical experience could cause a person to be more likely to be exposed to chant. However, this correlation only approaches significance, and I would recommend this specific relationship to be further tested.

Limitations

There were several limitations of this study that should be taken into account when interpreting these results. One is the low power caused by the low number of data sets acquired from the participants. Another is that this is an exploratory study to find certain properties of Plainchant, which has very little exploration in the literature. The potential interpretation of baseline differences simply being caused by resting is another. Also, the music background data was oddly skewed to have higher levels of music training and active music listening. This could be better controlled in future studies.

Further research

There are several areas of this study that could be expounded upon in the near future. One would be to run a similar study to this one, yet add a period of rest before the first baseline reading to ascertain if this study's results were caused by actual conditional effects of participants simply resting. Another could be to retest Plainchant with varying levels of familiarity. A study could be designed where participants would be exposed to chant on several occasions before the physiological measures are taken and have that compared to a control group. The sample size could also be expanded to include participants of other age groups, as this study exclusively used undergraduate participants.

Conclusions

Ultimately, the question must be asked as whether or not I have accomplished my main research question: can Sister Ruth Stanley's results with plainchant be replicated in a laboratory setting. The answer: partially. I found that, while chant did have positive effects on heart rate variance, it was not any more effective at increasing heart rate variability than any other condition. In terms of emotional self-report, chant did elicit low ratings in terms of arousal. However, chant also did not elicit the high valence response which would have been expected from an efficient music therapy stimulus. Even with these issues, this study has opened two new areas which can be used to more fully answer this question. First, the question of whether resting quietly had the effect of increasing heart rate variability needs to be answered, most likely with a similar study to the current one. If chant is still found to have a positive effect on heart rate variance, the idea of familiarity can be more fully explored. It is likely that individuals that have prior exposure to chant will respond with higher heart rate variability, which would ultimately support Sister Stanley's clinical experience. This is simply postulation, however, and warrants further experimentation.

References

Apel, W. (1990). *Gregorian Chant* (1st ed.). Bloomington, IN: Indiana University Press.

Bernardi, L., MD, Porta, C., MD, Casucci, G., MD, Balsamo, R., MD, Bernardi, N. F., MSc, Fogari, R., MD, & Sleight, P., MD. (2009). Dynamic interactions between musical, cardiovascular, and cerebral rhythms in humans. *Arrhythmia/Electrophysiology*, *119*, 3171-3180. doi: 10.1161/ CIRCULATIONAHA.108.80617410.1161/CIRC

Burkholder, J. P., Grout, D. J., & Palisca, C. V. (2010). *A history of western music* (8th ed.). New York City, NY: WW Norton and Company.

Burns, J., Labbe, E., Williams, K., & McCall, J. (1999). Perceived and physiological indicators of relaxation: As different as mozart and alice in chains. *Applied Psycophysiology and Biofeedback*, *24*(3), 197-202.

Carr, C., D'Ardenne, P., Slobada, A., Scott, C., Wang, D., & Priebe, S. (2011). Group music therapy for patients with persistent post-traumatic stress disorder – an exploratory randomized controlled trial with mixed methods evaluation. *Psychology and Psychotherapy: Theory, Research and Practice*, *85*, 179-202. doi: 10.1111/j.2044-8341.2011.02026.x

Dellacherie, D., Roy, M., Hugueville, L., Peretz, I., & Samson, S. (2010). The effect of musical experience on emotional self-reports and psychophysiological responses to dissonance. *Psychophysiology*, No-No. doi: 10.1111/j.1469-8986.2010.01075.x

Eerola, T., & Vuoskoski, J. K. (2011). A comparison of the discrete and dimensional models of emotion in music. *Psychology of Music*, *39*(1), 18-49. doi: 10.1177/0305735610362821

Ellis, R. J., PhD, Koenig, J., MA, & Thayer, J. F., PhD. (2012). Getting to the heart: Autonomic nervous system function in the context of evidence-based music therapy. *Music and Medicine*, *4*(2), 90-99. doi: 10.1177/1943862112437766

Etzel, J. A., Johnsen, E. L., Dickerson, J., Tranel, D., & Adolphs, R. (2006). Cardiovascular and respiratory responses during musical mood induction. *International Journal of Psychophysiology*, *61*(1), 57-69. doi: 10.1016/j.ijpsycho.2005.10.025

Frederickson, B. L., Mancuso, R. A., Branigan, C., & Tugade, M. M. (2000). The undoing effect of positive emotions. *Motive Emotion*, *24*(4), 237-258.

Gerra, G., Zaimovic, A., Franchini, D., Palladino, M., Giucastro, G., Reali, N., ... Brambilla, F. (1998). Neuroendocrine responses of healthy volunteers to `techno-music': Relationships with personality traits and emotional state. *International Journal of Psychophysiology*, *28*(1), 99-111. doi: 10.1016/S0167-8760(97)00071-8

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

Iwanaga, M., Kobayashi, A., & Kawasaki, C. (2005). Heart rate variability with repetitive exposure to music. *Biological Psychology*, *70*(1), 61-66. doi: 10.1016/j.biopsycho.2004.11.015

Lin, P., Lin, M., Huang, L., Hsu, H., & Lin, C. (2011). Music therapy for patients receiving spine surgery. *Journal of Clinical Nursing*, *20*(7-8), 960-968. doi: 10.1111/j.1365-2702.2010.03452.x

Miluk-Kolasa, B., Matejek, M., & Stupnicki, R. (1996). The effects of music listening on changes in selected physiological parameters in adult pre-surgical patients. *Journal of Music Therapy*, *33*, 208-218.

Nakayama, H., BEd, Kikuta, F., & Takeda, H. (2009). A pilot study on effectiveness of music therapy in hospice in japan. *Journal of Music Therapy*, *46*(2), 160-172.

Nater, U. M., Abbruzzese, E., Krebs, M., & Ehlert, U. (2006). Sex differences in emotional and psychophysiological responses to musical stimuli. *International Journal of Psychophysiology*, *62*(2), 300-308. doi: 10.1016/j.ijpsycho.2006.05.011

Nyklicek, I., Thayer, J. F., & Van Doornen, L. J. (1997). Cardiorespiratory differentiation of musically induced emotions. *Journal of Psychophysiology*, *11*, 304-321.

Russell, J. A. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*,*39*(6), 1611-1178.

Sandstrom, G. M., & Russo, F. A. (2010). Music hath charms: The effects of valence and arousal on recovery following an acute stressor. *Music and Medicine*, *2*(3), 137-143. doi: 10.1177/1943862110371486

Sarkamo, T., Pihko, E., Laitinen, S., Forsblom, A., Soinila, S., Mikkonen, M., ... Tervaniemi, M. (2010). Music and speech listening enhance the recovery of early sensory processing after stroke. *Journal of Cognitive Neuroscience*, *22*(12), 2716-2727.

Schubert, E. (2007). The influence of emotion, locus of emotion and familiarity upon preference in music. *Psychology of Music*, *35*(3), 499-515. doi: 10.1177/0305735607072657

Stanley, R., OSB. (2013). Origins and applications of music in chronic illness: Role of the voice, ancient chant scales, and autonomic nervous system. *Chronic Illness and Spirituality: Diverse Disciplinary, Religious, and Cultural Perspectives*.

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

APPENDIX 1

Instruments used:

Valence and Arousal Questionnaire

Please respond to the following four questions with regard to the sample you just listened to by selecting one number.

How much did the previous piece make you feel agitated?
Strongly Disagree 1 2 3 4 5 6 7 Strongly agree

How much did the previous piece make you feel happy?
Strongly Disagree 1 2 3 4 5 6 7 Strongly agree

How much did the previous piece make you feel sad?
Strongly Disagree 1 2 3 4 5 6 7 Strongly agree

How much did the previous piece make you feel serene?
Strongly Disagree 1 2 3 4 5 6 7 Strongly agree

APPENDIX 2

Emmanuel Music Background Questionnaire (modified)

Please first provide your basic information.
Code:__________
Please answer the following questions to the best of your knowledge.

1. Please rate your overall interest in Music according to the following scale (1 being not very interested, 3 being neutral, and 5 being very interested):

   1 □ 2□ 3 □ 4□ 5□

2. Please rate your overall Music ability according to the following scale (1 being poor, 3 being average, and 5 being Excellent):

   1 □ 2□ 3 □ 4□ 5□

3. How many hours per week do you spend listening to music?

4. What genre(s) do you listen to most? (check all that apply)

   - □ Classical
   - □ Jazz
   - □ Rock
   - □ Pop
   - □ Other: (please specify in space provided below)

5. Most of the time, when you listen to music, you are (select any that apply):

   - □ Actively engaged (sing along, tap the beat, etc.)
   - □ Highly aware of musical nuances such as key changes, harmonies, etc.
   - □ Passively listening
   - □ Not focused on the music, attending to a different task

6. About how many hours of musical activity do you engage in each week currently (e.g.

practice, performance):

7. 11. Have you ever had any formal training in music (please select one): YES / NO

Please continue this form if you answered YES to question 7 or are a self-taught musician, otherwise please go directly to question 13.

8. What type(s) of music training have you had? (check all that apply)
   - □ Private/small group lessons in instrument and/or voice
   - □ Institutional training
   - □ University degree in music - list degree: ______________
   - □ Self-taught

□ Other (please answer in the space provided below)

9. At what age did you begin to study music?

10. How long did your formal music training last?

11. How long has it been since you last participated in formal music lessons (please select one):

□ Currently have one
□ Or _____________ years

12. Please list any instrument(s) that you play (including voice) and the years you play each of

them, beginning with your primary instrument:

Instrument:	Years playing:
_____________________	_____________
_____________________	_____________
_____________________	_____________
_____________________	_____________
_____________________	_____________

13. If there is anything else that you feel is interesting or important about your musical background, please comment below:

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