Physiological Responses to Music

An Honors Thesis (PSYS 499)

by

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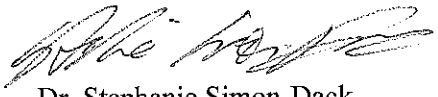

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May 2017

Abstract

The purpose of this study was to look at the effects hours spent practicing music per week, and the type of music played on the physiological responses of participants while listening to music. The skin conductance (SCL) and heart rate (HR) of 42 participants was recorded while they listened to 4 different pieces of music. It was found that the SCL of musicians, or people with one or more hours of practice a week, always decreased regardless of the song while non-musicians' SCL mean stayed around the baseline. When comparing the SCL of non-musicians to musicians there was much greater variability found in the non-musicians. In terms of group differences it is possible that there is an inhibition of the parasympathetic nervous system in musicians when listening to music. Non-musicians may also have some sensitization patterns to qualities of certain timbres that musicians do not; for example sensitization to the voice in a major mode or instruments in a minor mode.

Acknowledgements

I would like to thank Dr. Stephanie Simon-Dack for advising me through this project. Her help and encouragement throughout this thesis and my work, here on campus, as a whole has made this an enjoyable experience. She has taught and helped me a lot over the past four years and I owe a lot to her.

I also want to thank Dr. Holtgraves who has given a lot of advice and guidance on this study. It was a great experience to be able to work with him throughout this past year.

I would also like to thank my co-authors Anna Allen, Dakota Nicley, Megan Robbins, and Sam Robison who were a tremendous help this semester with collecting data for this thesis.

Finally, I would like to thank Cassie Aker and Anthony Knepp who gave me a lot of encouragement and help throughout this entire project. Without our weekly meetings to talk about our projects and help each other I doubt my thesis would not be what it is now.

Physiological Responses to Music

Music plays a key role in our psychological health, our memory, and even our ability to cope with stress. For instance, music therapy is used to help the language skills of people who suffer from dementia (Brotons & Koger, 2000). We find that music also plays a role in our memory. It has been found that music evokes more vivid autobiographical memories than other strong memory cues, like familiar faces (Belfi, Karlan & Tranel, 2016). Music can even be used as a coping mechanism for stressors (Grewe, Nagel, Kopiez, & Altenmüller, 2007). It is important that we understand the mechanisms underlying our cognitive and emotional responses to music in order to understand how it helps our psychological health.

There are some areas of music that have been extensively researched, like music appreciation, the difference between musicians and non-musicians, and the efficacy of therapy techniques; while other areas of music's effect on cognition, like timbre, have not. There is however a link between all of these variables and they all influence each other. For example timbre, harmonics, and chords are all combined by composers when writing music. This current study will analyze physiological responses to vocal and instrumental music between musicians, defined as individuals who study one or more hours a week, and non-musicians, defined as individuals who do not study music. We are looking at these two groups for several reasons. First, there have been many studies, discussed below, conducted that show enhanced cognitive abilities and auditory performance by musicians compared to non-musicians. The only major difference between these groups is musical training, which means that if we can understand the changes in cognition and the physiological responses that occur in the musically trained individuals we can use that information to improve music therapy and our psychological health.

There has been plentiful research into the cognitive and neurological differences between musicians and non-musicians, as seen below. However, there has not been much research in the different physiological responses of these groups when listening to vocal and instrumental music. Since music plays such an integral role in our society it is important to see how different groups perceive music differently and how this may contribute to differences in cognitive processing between the groups.

Physiological Studies

Labbe, Schmidt, Babin, and Pharr (2007) found that participants have reduced anxiety levels when they listen to classical or self-selected music compared to the other genres like heavy metal. These findings demonstrate that regardless of musical training there are certain variables in music that have a positive effect on the psychological health of people. A study conducted by Grewe, Nagel, Kopiez and Altenmüller (2007) found several variables that are involved in people experiencing cold chills. Cold chills are "measurable bodily reactions such as goose bumps or shivers down the spine, commonly called 'chills'". These variables include the personality of the listener, familiarity, and even the situation in which people listen to music. They also found that participants tend not to act towards acoustical triggers but rather patterns within the music. This finding points towards group differences caused by not only musical training and an individual's state of mind, but their interaction with the patterns in the music itself. Cold chills themselves are important to note because skin conductance is one of the main indicators of cold chills. This gives evidence to the importance of skin conductance as a mechanism for demonstrating enhanced responsiveness to musical patterns. According to a chapter found in the Oxford Handbook of Music Psychology (Hallam, Cross, & Thaut, 2016) physiological responses can be complicated to interpret. They mention that there is a trend for

people to have increased physiological responses, mainly heart rate and skin conductance, to stimulative music and decreased responses to sedative music, but it is not always the case. This points to the fact that different patterns and variables in music will elicit different kinds of responses, both physiological and cognitive.

There is more to music than just listening to music. People create music, whether through composition or through performance. Another variable in music that is studied is the difference between listening to music and performing music. Kreutz, Bongard, Rohrmann, et al. (2004) conducted an experiment in two parts. In one part participants listened to choral music, in the second they sang choral music. Saliva samples were taken before and after each part. Participants also filled out the Positive and Negative Affect Schedule (PANAS) psychometric scale for measurement of emotional state before and after each condition. It was found that singing leads to increases in positive affect and levels of S-IgA, which is an immunoglobulin that is critical for immune functioning in the mucous membrane, while negative affect is reduced. The study found several interactions, where after participants sang they had an increase in positive affect, emotional state, but not after only listening to music. Also, just listening to the music lead to an increase in negative affect, but negative affect decreased after the singing condition. In terms of protein secretion the study found that S-IgA levels increased in the singing condition and cortisol decreased in the listening condition. This demonstrates that there are more benefits to singing music compared to just listening to it.

Since there are so many different variables that influence cognitive and physiological responses to music it is necessary to test them separately. Pereira, et al (2011) ran a study that looked at how much familiarity and aesthetic preferences matter when it comes to music and emotions. They also wanted to know which of the two contributed most when it came to

recruitment of the limbic and reward systems of the brain. Participants were exposed to two parts. First they were exposed to 110 sections of songs and were asked to list familiarity and how much they liked the song on a Likert scale (1-10). Then they listened to 48 songs, half familiar, half unfamiliar, while their brain activation patterns were being studied through an fMRI. It was found that while musical preferences only had a marginal effect on the neural components, there was a significant main effect for familiarity. Familiarity was found to play a key role in the neural systems involved in the emotion-related systems. Our neural pathways are strengthened from repeated use, thus familiar music will have a stronger effect on us on a cognitive and neurological level. They also found that songs that were familiar scored higher on the Likert scale than unfamiliar songs regardless of whether they were liked or disliked. These findings relate back to both cognitive and neurological backgrounds of music. By listening to familiar songs we have strengthened the neural pathways that are used in processing those songs. We have also created schemas for what we consider good music, when we recognize a song it is either because we have placed it within that schema or if it does not fit the schema we must justify why we recognize it.

Musical Training

Perhaps the most studied aspect of music is the difference between musicians and non-musicians. In a study conducted by Musacchia, Sams, Skoe, and Kraus (2007) temporal and spectral resolution were used to see if subcortical processing was influenced by musical experience. Overall, results suggest that complex musical training influences encoding mechanisms for peripheral sensory structures, specifically brainstem activation during stimuli onset and phase-locking when relating to the fundamental frequency. Neurologically musicians have subcortical specializations that enhance auditory and audiovisual encoding for both speech

and musical sounds. This shows that musical training strengthens neural pathways involved in musical processing. A more cognitive approach was taken in a study by Schön, Magne, and Besson (2004) who looked at the difference between musicians and non-musicians when fundamental frequencies (F0) in both music and speech were manipulated. A fundamental frequency is the lowest frequency produced in a soundwave. For example, if a Middle C was played on a piano a waveform is created and the fundamental frequency would be the trough of that waveform. They found that musicians noticed weak manipulations of the F0 better than non-musicians. Musicians also had a shorter onset latency than non-musicians when looking at the brain's electrical potentials. This shows that musicians expectations for how a chord or frequency should sound is much stronger and more frequently used, allowing them to notice weaker F0 manipulations much faster than non-musicians.

While there are many differences between musicians and non-musicians on both a neurological and cognitive level, there are some neurological backgrounds that are the same for both groups. Lee, Skoe, Kraus, Ashley (2009) conducted a study using two different musical intervals, the major sixth (E3 and G2) and the minor seventh (E3 and F#2.). Twenty-six participants, grouped into musicians, non-musicians, and amateur musicians, were presented to two intervals, the consonant interval and the dissonant interval. All neural responses were recorded with four scalp electrodes. It was found that musicians' responses to the harmonic components of an upper tone in musical intervals was significantly enhanced. This was a very surprising find since the lower tone harmonics have a greater intensity. There was also a strong, positive correlation found between the length of musical training and the amount of upper tone subcortical enhancements. Another surprising result was that in the dissonant condition (E3 and F#2) non-musicians showed a greater response for harmonics of the lower tone and for a

combination tone compared to the responses of musicians. Finally, it was found that musicians' representation of the temporal envelope of a stimulus was more accurate than that of a non-musician. In psychoacoustics an envelope is the concept of constant frequency, the temporal envelope is the slow variation in amplitude of the sound over time (Moon & Hong, 2014). Temporal envelopes are measured through fluctuations in the short-term firing in auditory neurons.

Menon and Levitin (2005) conducted an fMRI study looking at the reward and affective components used when listening to music. They found significant activations in a network of subcortical areas that included the nucleus accumbens (NAc), the ventral tegmental area (VTA), and the hypothalamus. This suggests that these three structures mediate neural responses to all rewarding and affective aspects of music and is thus a system that is used heavily by both musicians and non-musicians. It is important to examine differences between these two groups, because by studying them we see the benefits of musical training and we can use that information to improve music therapy and our psychological health. These changes however must be built on a foundation of neurological and cognitive processes that are fundamental for processing and appreciating music.

Present Research

Differences of the physical brain or neural processing in musical appreciation, and even physiological responses to music have been studied in musicians and non-musicians. In this study we looked at the different physiological responses in musicians and non-musicians when they are listening to choral music and instrumental music. Pereira, et al (2011) used a large number of songs as stimuli for their familiarity study, but only pop and rocks songs were used. None focused on just the instrumental aspect of music. It was expected that vocal music will

elicit a significantly greater physiological response than instrumental music. This was because the voice is evolutionally the oldest instrument there is and it is logical to assume that humans have evolved to have a great enjoyment to vocal music. Not only have we developed a pre-disposition to the human voice but we as a species have the capacity for language. Over time we have developed highly sophisticated neural pathways for comprehending and creating speech, all of these pathways are used in vocal music. It was also predicted that musicians will have a greater physiological response to instrumental music than non-musicians. This was because musicians are trained professionally in both vocal and instrumental music, and their representation of both the fundamental frequency and harmonics are enhanced neurologically. Finally, there was expected to be an interaction between music type and group. Musicians are expected to have a higher physiological response to instrumental music compared to non-musicians but no significant difference is expected with vocal music. This was expected because language is such a large predisposition and all people listen to vocal music on a regular basis. This will eliminate differences in musical training just due to the amount of the exposure that non-musicians have to vocal music.

Method

Participants

In this study 42 people participated aged 18-31 (M = 20.71). Twenty participants were male and twenty-two participants were female. Participants also consisted of twenty-eight *White* participants, nine *Black* participants, one *American Indian or Alaskan Native*, and three *Other*. Participants consisted of nine *Freshman*, twelve *Sophomores*, fourteen *Juniors*, three *Seniors*, two *2nd Year MA students,* and one *2nd Year DA student.* Participants were placed into two groups, musicians and non-musician. Musicians were considered those who practiced one or more hours a week. These criteria have been chosen for several reasons. First, by practicing

your chosen instrument every week guarantees that the neural pathways are being used on a regular basis and that they are proficient. While this did not guarantee that musicians would have multiple years of training, it did guarantee that they were currently playing and had not stopped years before. Any participant who did not meet these criteria were placed into the non-musician group. All participants from the School of Music and the PSYS 100 and MKG 300 students were put into groups based on those criteria. PSYS 100 participants were given one credit hour to attribute to their class; participants from the School of Music had their names put into a raffle for four different gift cards to Starbucks. All gift cards were worth $25.

Materials

A self-created musical training inventory was used in order to determine the musical background of the participants, years of formal training, hours practiced every week, and any potential hearing deficits (see Appendix A). Two different informed consent forms were made, one for the musician group and one for the non-musician group.

Music selection. Music was selected based upon obscurity. All song selections were made, with the help of Ball State's Choral director, so that most, if not all, participants would not be familiar with the music. Familiarity is a large influence on an individual's neural and physiological response (Pereira, et al., 2011). It is important to isolate the factors we are looking at so that other factors, like familiarity, do not influence our factors of interest. Participants will report familiarity of the piece after each condition, by answering yes or no to the question, to make sure that all pieces are unfamiliar. A certain set a criteria was used for selecting pieces in the two desired genres of music. Choral music is considered music that consists solely of vocalists and no instrumental accompaniment. Instrumental music is considered music that is solely orchestral and has no supporting vocal music with it. All songs were also kept consistent

in terms of tempo (BPM) and musical key. Four songs were chosen to be used as stimuli for participants, two choral pieces and two orchestral pieces The two orchestral pieces chosen were *Three Pieces in the Old Style, 1st Movement* (2:18, BPM = 97.80, major) by Henryk Gorecki and *Orchestra Piece #1* (2:05, BPM =97.80, minor) by Koji Kondo. Songs selected for the choral pieces were *Ubi Caritas et Amor* (2:32, BPM = 99.00, major) by Maurice Durufle and *Einförmig is der Liebe Gram* (3:01, BPM = 100.25, minor) by Johannes Brahms.

Procedure

Participants were given the informed consent form and the musical training inventory when they first arrived. iWorx 214 Psychophysiology Teaching Kit (iWorx Systems, Inc.) was used in order to record physiological measures. They were asked to wash their hands with soap and water before skin conductance level (SCL) data collection. Once participants did this two electrodes were attached to the middle and index finger of the left hand and a pulsar electrode, for heart rate, was placed on their left thumb. Sound proof headphones were worn by the participants when being exposed to the stimuli. All participants were exposed to a brown-noise sound for two minutes in order to establish a baseline. Once baseline was established participants listened to the four selected songs with one minute of brown-noise between each song. All songs were played counterbalanced fashion to avoid confounding variables of order. During the experiment participants either heard the stimuli in the order of *Three Pieces in the Old Style, 1st Movement, Einförmig is der Liebe Gram, Orchestra Piece #1,* and *Ubi Caritas et Amor* or *Einförmig is der Liebe Gram, Three Pieces in the Old Style, 1st Movement, Ubi Caritas et Amor,* and *Orchestra Piece #1.*

Results

Preliminary

All data files were cleaned using a Heart Rate (HR) filter in LabScribe3. All heart rate artifacts below 30 bpm and above 200 bpm were removed from the file. One file was too corrupted to clean and was removed from analysis, leaving 41 participants. Also, each participants' stimuli responses were subtracted from their baseline in order to get accurate stimuli responses that differed from baseline physiological reactivity.

Hypothesis Tests

In this study there were three main hypotheses:

1. I hypothesized that vocal music will elicit a significantly greater physiological response than instrumental music.
2. I also predicted that musicians will have a greater physiological response to instrumental music than non-musicians.
3. Finally, I expected there to be an interaction between music type and group. Musicians were expected to have a higher physiological response to instrumental music compared to non-musicians but no significant difference was expected with vocal music

For these analyses musicians were defined as anyone who practices one or more hour every week; the musician group had 22 participants and the non-musician group had 19 participants.

Analysis of Variance tests. Two 2 x 2 x 2 Group (Musician vs. Non-musician) by Type (Orchestral vs. Choral) by Key (Major vs. Minor) Analysis of Variances were conducted; one to examine differences in skin conductance levels (SCL) and one to examine differences in heart rate (HR). The first ANOVA examined HR responses and no significant effects were found (all

ps' > .05). In the second ANOVA that examined SCL responses, a significant effect for Group was found for SCL, $F(1, 39) = 6.204$, $p < .05$, *Partial Eta*$^2 = .137$. While non-musicians' SCL responses stayed around the mean or went up, musicians' SCL responses dropped below the mean for all stimuli. Even though this significant main effect was found it did not support my second hypothesis. A significant Type by Key interaction found, $F(1, 39) = 5.070$, $p < .05$, Partial *Eta*$^2 = .115$ (Figure 1). When the music was orchestral there was a greater reduction in SCL response to music in the major key ($M = -.345$) than the minor key ($M = .004$), but when music was choral there was a greater response for the minor key ($M = -.267$) compared to the major key ($M = -.010$). Finally a significant Type by Key by Group interaction was observed. Group was analyzed for each Type by Key combination. Results found that there was a significant Type by Key interaction for non-musicians, $F(1, 18) = 7.018$, $p < .05$, Partial *Eta*$^2 = .206$. When the music was orchestral non-musicians' response decreased for major music ($M = -.341$) and increased for minor music ($M = .374$). When the music was choral non-musicians' responses increased for major music ($M = .365$) and decreased for minor music ($M = -.136$). For a closer look see Figures 1 and 2. No significant Group by Type interaction was found, $F(1, 39) = 1.356$, $p > .1$, *Partial Eta*$^2 = .034$. None of the interactions supported my third hypothesis. There was also no significant main effect for Type, $F(1, 39) = .317$, $p > .1$, *Partial Eta*$^2 = .008$ and did not support my first hypothesis.

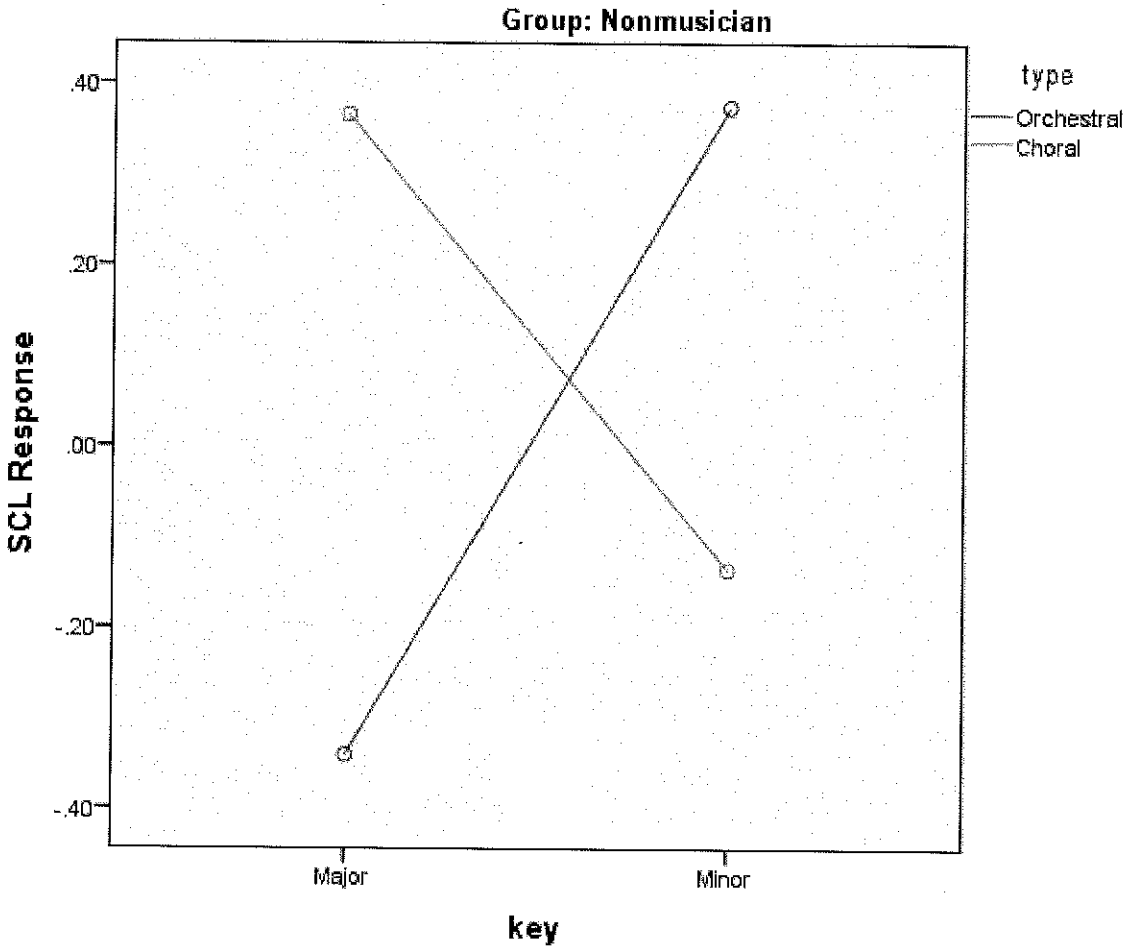

Figure 1. SCL Type by Key interaction for non-musicians.

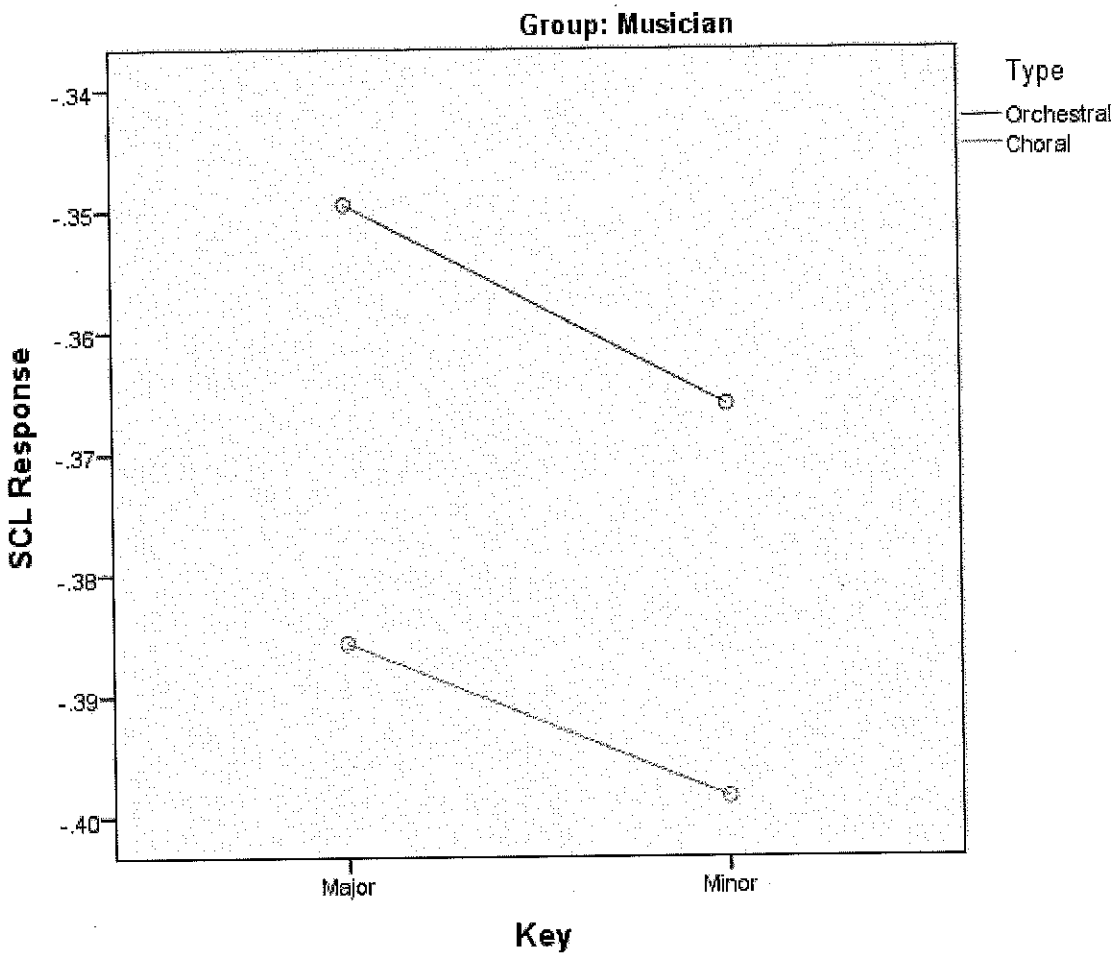

Figure 2. SCL Type by Key responses for musicians.

Post-hoc Analyses

In general, none of the hypothesis were supported by the results, but there were some results that needed to be examined further. Namely, I wanted to know if there were significantly different responses for individual songs in case the difference found in the initial analyses were being driven more by a song itself than by the type of music or key in which the music was presented.

Two 2 x 4 Group by Song ANOVA's were conducted to examine effects on SCL and HR responses. The first ANOVA examined HR responses and no significant effects were found (all

ps' > .05). The second ANOVA examined SCL responses. Mauchly's Test of Sphericity was significant and Greenhouse-Geisser adjustments were used. A significant main effect for Song was found, $F(1.306, 50.946) = 4.142$, $p < .05$, *Partial Eta*$^2 = .096$. *Three Pieces in the Old Style, 1st Movement* had the largest overall response ($M = -.345$), *Einförmig is der Liebe Gram* the second largest ($M = -.267$), *Ubi Caritas et Amor* the third ($M = -.010$), and *Orchestra Piece #1* the smallest overall response ($M = .004$). There was also a significant Song by Group interaction found, $F(1.306, 50.946) = 4.407$, $p < .05$, *Partial Eta*$^2 = .102$. Results for both can be seen in Figure 2. In order to more closely examine the interaction, an Independent Samples T-test was conducted to compare group SCL means. It was found that for *Three Pieces in the Old Style, 1st Movement* there was no significant difference between musicians ($M = -.3495$) and non-musicians ($M = -.3409$), $t(39) = -.85$, $p > .1$. For *Einförmig is der Liebe Gram* there was a marginally significant difference between musicians ($M = -.3984$) and non-musicians ($M = -.1357$), $t(39) = -1.835$, $p < .1$. For the SCL means for both *Orchestra Piece #1* and *Ubi Caritas et Amor* Levene's test was significant and adjustments were made accordingly. For *Orchestra Piece #1* there was a significant difference between musicians ($M = -.3660$) and non-musicians ($M = .3736$), $t(23.935) = -2.608$, $p < .05$. For *Ubi Caritas et Amor* there was a significant difference between musicians ($M = -.3856$) and non-musicians ($M = .3653$), $t(22.135) = -2.106$, $p < .05$. For SCL means reference Table 1.

Table 1:
Skin Conductance means for musicians and non-musicians.

Stimuli	Group	SCL Mean	Stimuli Type	Stimuli Mode
SCL1mB	Musician	-.3495	Orchestral	Major
SCL1mB	Nonmusician	-.3409	Orchestral	Major
SCL2mB	Musician	-.3984	Choral	Minor
SCL2mB	Nonmusician	-.1357	Choral	Minor
SCL3mB	Musician	-.3660	Orchestral	Minor
SCL3mB	Nonmusician	.3736	Orchestral	Minor
SCL4mB	Musician	-.3856	Choral	Major
SCL4mB	Nonmusician	.3653	Choral	Major

Note. Means of musicians and non-musicians for each stimuli. SCL1 = Three Pieces in the Old Style, 1st Movement, SCL2 = Einförmig is der Liebe Gram, SCL3 = Orchestra Piece #1, and SCL4 = Ubi Caritas et Amor

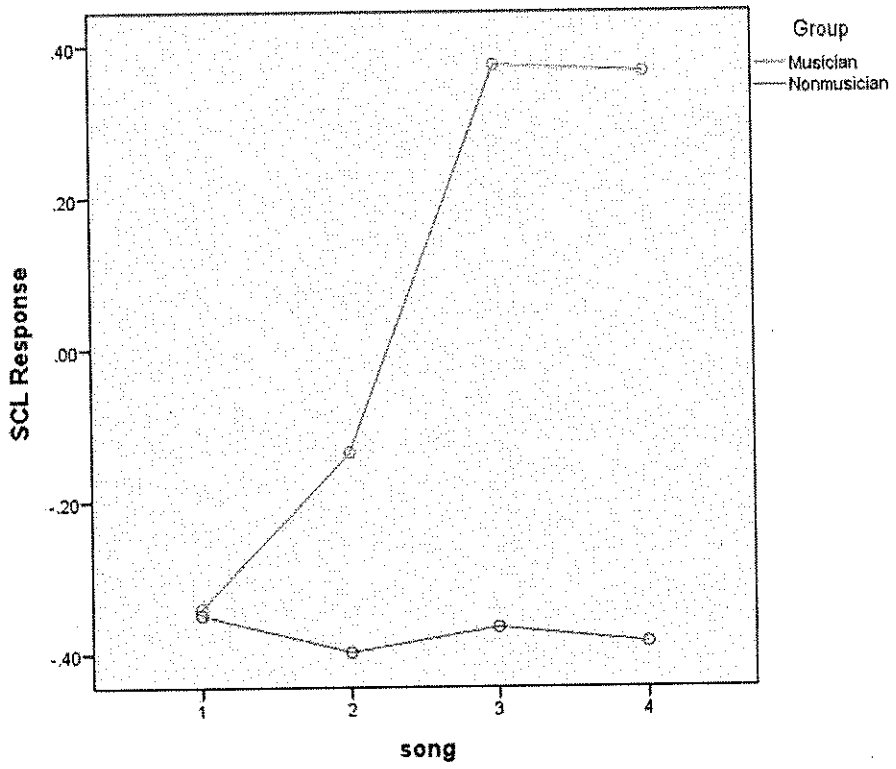

Figure 3. This figure shows the mean scores for Musicians and Non-musicians for each song. Musicians are the blue line and Non-musicians are the green line.

Discussion

In past research there have been distinct differences seen between musicians and non-musicians. Musicians generally tend to have enhanced neurological processing with things like stimuli onset and phase-locking to the fundamental frequency (Musacchia, Sams, Skoe, & Kraus, 2007) or even representation of higher pitches in intervals (Lee, Skoe, Kraus, & Ashley, 2009) when compared to non-musicians. These differences appear to come from the fact that musicians receive complex musical training in both performing and listening to music while non-musicians do not.

There are also other aspects of music that have direct applications in the peoples' health. For example, it has been found that music evokes more vivid autobiographical memories than other strong memory cues, like familiar faces (Belfi, Karlan & Tranel, 2016), music therapy is used to help the language skills of people who suffer from dementia (Brotons & Koger, 2000), and it is even used by most people as a coping mechanism for stressors (Grewe, Nagel, Kopiez, & Altenmüller, 2007). The purpose of this research was to look at the effects of musical training, hours spent practicing music per week, and the type of music played on the physiological responses of participants while listening to music. Specifically, the effects of hours spent practicing per week on the participants' physiological responses to orchestral and choral music.

In general, we found no evidence to support the hypotheses. The first hypothesis was that vocal music would elicit a significantly greater physiological response than instrumental music, but no significant difference was found between these two types. The second hypothesis

was that musicians will have a greater physiological response to instrumental music than non-musicians. No significant difference was found between non-musicians and musicians for orchestral music however. Though it is important to note that for *Orchestra Piece #1* musicians had a decrease in their skin conductance (SCL) while non-musicians had in increase in their SCL. The third hypothesis of this study was that an interaction between music type and group. Musicians were expected to have a higher physiological response to instrumental music compared to non-musicians but no significant difference was expected with vocal music. Since there was no significant group difference for orchestral music it is easy to conclude that this interaction was not seen in the results of this study.

While none of the predicted hypotheses were supported, several interesting effects were found outside of my hypothesis. Firstly, all significant findings were associated with skin conductance levels (SCL) and not with heart rate. There was a main effect for Group where non-musicians' SCL, on average, was slightly greater than the baseline but musicians' SCL always decreased. What we suspect here is that musicians are having an inhibition of their parasympathetic nervous system while non-musicians have little inhibition. Music evokes vivid autobiographical memories more strongly than other memory cues, like familiar faces (Belfi, Karlan & Tranel, 2016). Memories not only store information of a certain event, but also the emotions we experienced at that time. Since musicians naturally practice and perform music on a regular basis it is very possible that listening to music evokes memories of performances that puts them in an emotional state that inhibits the parasympathetic nervous system. There was also a Type by Key by Group interaction that was found. When participants were non-musicians their SCL decreased for orchestral music when it was in a major mode, but had an increase in SCL response when orchestral music was in a minor mode. When they listened to choral music

their SCL decreased when listening to a piece in a minor mode, but had an increase in SCL response when listening to a piece in a major mode. It is very possible that non-musicians do not have memories of music that neither inhibits nor excites their parasympathetic nervous system since most of their musical exposure is the music they listen to on an everyday basis. They may also be sensitized to specific qualities in timbre for choral and orchestral music, thus decreasing or increasing their SCL response depending on quality of timbre in the type and key of the music. Another possibility is that, since this study only used a partial counterbalance for the stimuli, there is an interaction with stimuli order instead of a Group by Type by Key interaction. There was also a consideration that it may not be a Type by Key interaction that is influencing physiological responses but rather individual songs. Here we found that the two groups had almost identical SCL means for *Three Pieces in the Old Style, 1st Movement*, which is orchestral and in a major mode, a marginally significant difference in *Einförmig is der Liebe Gram*, which is choral and in a minor mode, where both SCL means dropped below baseline but the musicians' SCL mean decreased more than the non-musicians, a significant difference in *Orchestra Piece #1*, which is orchestral and in a minor mode, where musicians' SCL mean decreased but non-musicians SCL mean increased, and finally a significant difference in *Ubi Caritas et Amor*, which is choral and in a major mode, where once again the musicians' SCL mean decreased and the non-musicians' increased. The biggest variable that distinguishes these songs are the key that they are in. While both *Einförmig is der Liebe Gram* and *Ubi Caritas et Amor* are both choral pieces, non-musicians' SCL responses increased for the major piece, *Ubi Caritas et Amor,* and decreased for the minor piece, *Einförmig is der Liebe Gram.* All four songs were controlled for tempo, time, and language for the choral pieces. *Ubi Caritas et Amor* and *Orchestra Piece #1* both had SCL increases for non-musicians, but they are different types

of music and in terms of key they are both in different keys. Thus, it is much more likely that the results we see are based much more in the Type by Key interaction than by songs individually. Overall, it is very possible that non-musicians' are more reactive to music overall because do not practice or perform music on a regular basis.

There are several possibilities as to why my hypotheses were not supported by the findings. The most likely however is that when it comes to physiological responses the type of music being played is not as big of a variable compared to other variables, like musical key. When it comes to the exploratory research that was conducted after the hypotheses there are two possibilities. In this study the major factor can either be viewed as an interaction between the types of music played, orchestral or choral, and whether it was in a minor or major mode, or that the differences were in the individual songs. The most likely conclusion is that we were seeing an interaction between the type of music and what key it was in. If you compare Figure 3 to Figure 1 you will see that the same interaction can be seen in both figures. Songs one, orchestral, and four, choral, in Figure 2 are in a major mode while songs two, choral, and three, orchestral, are in a minor mode. It is also important to note that this interaction is only seen in non-musicians, musicians had a decrease in SCL regardless of the type of music nor whether it was in a major or minor mode. One thought is that it may be a sensitization, lower action-potential threshold level, pattern to timbre, sound quality, which is influenced by musical training. For instance non-musicians may be sensitized to instrumental music when it is in a minor mode and vocal music when it is in a major mode. Musicians always have a habituated response because not only are they exposed to both voice and orchestra pieces in major and minor modes often, but they are taught transposition of music and are trained in an analytical response to the timbre of a piece, regardless of key. It should also be noted that heart rate (HR)

never deviated significantly from the baseline. It can thus be assumed that none of the stimuli in this experiment had any effect on HR regulation and only influenced other aspects of the peripheral nervous system. HR regulation is also more cognitive than SCL, which is a sympathetic response, so it may be that my stimuli did not influence participants as much on a cognitive level but influenced their sympathetic system. As mentioned in the Oxford Handbook of Music Psychology (Hallam, Cross, & Thaut, 2016) physiological responses can be complicated to interpret. While people normally have changes in both heart rate and skin conductance based on whether it is a stimulative or sedative song, this is not always the case. These physiological measures can be influenced by different patterns in the music and the individual's own emotional and cognitive response to the music.

Limitations

There are several limitations that can be found with this study. Like a lot of university studies this study only used a sample from the university itself and lowers ecological generalizability. Another limitation is that while we controlled potential confounding variables like music key, tempo, familiarity, and language, it is very possible that some confounding variables were missed. One possible confounding variable is stimuli order. This study only used a partial counterbalancing method for stimuli presentation, thus two songs rotated between the first and second position and two songs rotated between the third and fourth positions. The interaction that was found could be due to a decrease in attention during the second half of the experiment, causing an increase in their skin conductance response. It is also worth mentioning that we treated musical training as a categorical variable. There has been research showing that there are some instances where if you treat musical training as a categorical variable you find significant results that you might not find if you had treated it as a continuous variable. Lastly,

this experiment only used four songs as stimuli. These songs were also broken down into two choral songs, one in a minor mode and one in a major mode, and two orchestral songs, one in a minor mode and one in a major mode. While possibly sufficient for this initial study it limits the data that was collected.

Future Research

Given the unexpected results that were found, follow up research will be required to answer the questions that were raised by these results. One interesting phenomenon to investigate is the fact that for *Orchestra Piece #1 and Ubi Caritas et Amor* non-musicians had a positive SCL response while musicians had a negative SCL response. Since non-musicians had a negative response for *Three Pieces in the Old Style, 1st Movement* and *Einförmig is der Liebe Gram*, it is possible that *Orchestra Piece #1 and Ubi Caritas et Amor* have some quality that is not present in the other two stimuli that causes this SCL increase in people who do not have musical training. Other similar studies could also be conducted to see if these results hold over different genres of music, since only orchestral and choral music were used. Finally it would be worthwhile to investigate the interaction seen between the minor and major modes with the orchestral and choral music. Since each category only had one data point in this study it would be easy increase the number of stimuli presented in order to get stronger results.

Conclusion

This study did end up demonstrating interesting results that have several implications. The group difference between non-musicians and musicians, those who practice at least an hour a week, were interesting even though the fact that there was a difference is not surprising. This difference leads to several possibilities in both sympathetic nervous system responses to music

and also music's relations to memory and emotions. The Group by Type by Key interaction also led to some very interesting possibilities. On a neurological level, habituation and sensitization are things that happen normally to us perceptually. The potential tie of non-musicians having sensitization to certain types of music when they are in certain keys could lead to some very interesting findings on the effects of musical training on psyche. This of course could directly impact music therapy and could produce different kinds of interventions than the ones that are being used presently. One example of this is looking at the regulation of musicians' sympathetic nervous system for music compared to non-musicians'. While we may not be able to predict how a certain piece of music will effect a non-musician on a physiological level, musicians tend to have a much more regulated response. This could allow for a more specific intervention in music therapy for patients who still actively play music since it would be easier to predict the physiological responses of those patients for these kinds of music. For patients who do not play, or sing, music it could be beneficial to bring in musicians to teach them how to play or sing. This musical training could be especially helpful for individuals who suffer from Dementia. As previously stated, music evokes vivid autobiographical memories much more strongly than other memory cues, like familiar faces (Belfi, Karlan, & Tranel, 2016). This would be especially beneficial if the musician focused on teaching these patients to play songs from their childhood or from important events in their lives, since these will either have had a lot of rehearsal or strong emotions tied to them. Playing music is also stimulating on both a cognitive and physical level and would help individuals use these abilities on a regular basis.

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Appendix

Informed Consent

Physiological Responses to Music

Study Purpose and Rationale

The purpose of this research project is to examine the physiological responses to different kinds of music between musicians and non-musicians; specifically the effect that formal musical training has on physiological responses.

Inclusion/Exclusion Criteria

To be eligible to participate in this study, you must be at least 18 years old.

Participation Procedures and Duration

During this study you will complete a questionnaire to assess demographic information and formal musical training. You will then be prepped for the physiology study, having your heart rate and skin conductance (sweat) measured by electrodes that will be placed on your fingers, wrists, and ankles. Once the electrodes have been placed you will sit as still as possible while you listen to white noise for two minutes. Then, you will listen to a few musical pieces with one minute of white noise in between each piece. Throughout the musical pieces and white noise your physiological responses will be recorded. In between each song you will be asked about the familiarity of the piece, only a yes or no answer is required. Once you have listened to all of the songs we will take the electrodes off and you will be free to go. This experiment should take approximately 30 minutes to complete. Participants will have their name put into a raffle for one of four Starbucks gift cards worth $25.

Data Confidentiality or Anonymity

All data that is collected during this study will remain confidential and there will be no names or identifying information in any publication or presentation of the data

Storage of Data

Informed consent documents and questionnaire response will be kept in the research lab. Physiological data will by entered into a software program and stored of the researcher's password-protected computer. Collected data will be kept for an indefinite amount of time for the purpose of future research analyses. Only members of the research team will have access to the data.

Risks or Discomforts

There are no perceived risks for participating in this study. However, it is possible that you may feel some discomfort while being prepared for the physiological recording. You may quit the study at any point you feel uncomfortable or do not wish to continue.

Who to Contact Should You Experience Any Negative Effects from Participating in this Study

Should you experience any feelings of anxiety, there are counseling services available to you through the Ball State University Counseling Center in Muncie, 765-285-1736.

Benefits

There are no perceived benefits for participating in this study.

Voluntary Participation

Your participation in this study is completely voluntary and you are free to withdraw your permission at any time for any reason without penalty or prejudice from the investigator. Please feel free to ask any questions of the investigator before signing this form and at any time during the study.

IRB Contact Information

For one's rights as a research subject, you may contact the following: For questions about your rights as a research subject, please contact the Director, Office of Research Integrity, Ball State University, Muncie, IN 47306, (765) 285-5070 or at irb@bsu.edu.

Physiological Responses to Music

****

Consent

I, _____, agree to participate in this research project entitled, *Physiological Responses to Music*, I have had the study explained to me and my questions have been answered to my satisfaction. I have read the description of this project and give my consent to participate. I understand that I will receive a copy of this informed consent form to keep for future reference.

To the best of my knowledge, I meet the inclusion/exclusion criteria for participation (described on the previous page) in this study.

_____ _____

Participant's Signature Date

Researcher Contact Information

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Informed consent documents and questionnaire response will be kept in the research lab. Physiological data will by entered into a software program and stored of the researcher's password-protected computer. Collected data will be kept for an indefinite amount of time for the purpose of future research analyses. Only members of the research team will have access to the data.

Risks or Discomforts

There are no perceived risks for participating in this study. However, it is possible that you may feel some discomfort while being prepared for the physiological recording. You may quit the study at any point you feel uncomfortable or do not wish to continue.

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Musical Training Inventory
Participant ID:_____

Demographics:

1. DOB: _____

2. What is your ethnicity?

A. American Indian or Alaska Native

B. Asian

C. Black or African American

D. Native Hawaiian or Other Pacific Islander

E. White

F. Hispanic/Latino/Latina

G. Other

3. School Year: _____

4. Do you have any hearing deficits?
-Yes ____
-No ____

Musical Inventory:

1. Do you play an instrument (including voice)?
-Yes ____
-No ____

2. If so, how many years of formal training have you had?

_____

3. On average, how many hours do you practice a week?

_____

Familiarity Inventory

1. Musical Piece #____

Was this piece familiar to you?
-Yes ____
-No ____

2. Musical Piece #____

Was this piece familiar to you?
-Yes ____
-No ____

3. Musical Piece #____

Was this piece familiar to you?
-Yes ____
-No ____

4. Musical Piece #____

Was this piece familiar to you?
-Yes ____
-No ____