Effects of Different Auditory Stimulation on Physiological Stress Response

Mikaela Bray, Nicholas Shein, Ayyan Arshad, Natasha Voytovich, Markayle Schears, Caroline Remmers

University of Wisconsin - Madison, Physiology 435
Lab 602, Group 7

Keywords: Blood Pressure, Electrodermal Activity, Genre, Heart Rate, Music, Stress, Test Anxiety
Abstract

Stress, such as that elicited by test anxiety, can be caused by many factors. Because the body reacts to stress in a variety of ways, several measurements can be obtained to quantify the stress response. Listening to music is one coping mechanism that has become popular among young adults. Music has been seen as a cost-effective stress management tool and has successfully lowered serum cortisol levels when used before a stressful stimulus (Thoma et al. 2013). However, a less explored topic is how different genres of music can affect stress levels. This experiment explores how four different genres of music alter stress levels while subjects take a stress inducing high level math test. The four genres used were electronic dance music, hard rock, classical, and reggae. Stress levels were measured using heart rate, blood pressure, and electrodermal activity. No statistical difference was found among the musical genres in their ability to impact stress levels through these three variables.

Introduction

College-aged individuals are subjected to different forms of stress every day, such as pressures related to work, school, relationships, finances, and health. A prevalent form of stress experienced across all college campuses is test anxiety. Test anxiety is a condition of perceived nervousness, worry, and emotional strain specific to test-taking (Spielberger 2010). In addition to psychological strain, test anxiety has numerous physiological effects, including nausea, fatigue, increased blood pressure and heart rate, dry mouth and restlessness (Spielberger 2010). It is thought to negatively impact individual test performance, as students with lower test anxiety tend to perform better than their peers with high levels of test anxiety (Retegui 2006). Because standardized tests, performance evaluations, and entrance exams are requirements for virtually
all undergraduate and graduate programs, the stress of test anxiety deserves research attention for effective prevention and treatment methods.

Stress, such as that elicited by test anxiety, can be caused by many factors. The mechanisms of how certain stressors interact with each other is not well understood. Stress is defined as any actual or perceived threat to homeostasis, while the stress response is how the body reacts to the stressor (Schneiderman et al. 2005). Stress can lead to the activation of the hypothalamic-pituitary-adrenal (HPA) axis, resulting in cortisol secretion (Windmaier et al. 2015). Cortisol plays a leading role in the sympathetic nervous system and some of its effects include: increased heart rate, blood pressure and skin conductance (Tsugosis 2016). Cortisol secretion is a natural and vital response to threatening stimuli, but prolonged exposure can lead to serious health complications such as, osteoporosis, muscle atrophy, immunosuppression, atherosclerosis and high blood pressure (Windmaier et al. 2015). Because the body reacts to stress in a variety of ways, several measurements can be obtained to quantify the stress response. Salivary cortisol levels, heart rate, blood pressure, and skin conductance have been used to successfully represent stress responses (Tsugosis 2016).

Despite the adverse causes and effects of elevated stress levels, one out of four young adults and one out of ten older adults do not believe that they do enough to cope with stress (APA 2015). Therefore, there is a great need for more research on how to effectively manage, cope and prevent stress in our country. Listening to music is one coping mechanism that has become popular among young adults. Music has been seen as a cost-effective stress management tool and has successfully lowered serum cortisol levels when used before a stressful stimulus (Thoma et al. 2013). However, a less explored topic is how different genres of music can affect stress levels. Support for this topic is mixed in existing scientific literature where varying genres,
measurements of stress, and models leave room for clarification. For example, a study done by Chang et. al concluded that 30% of people had increased stress levels when listening to certain music (Chang et al. 2017). In contrast, other research has found no significant differences in physiological stress responses when different types of music are played (Marshall and Tomcala, 1981).

To confront this gap in knowledge and discrepancies in findings, the aim of this study is to thoroughly explore the effects of music within the complex human stress response. On a campus where music and exams are abundant, this study aims to examine the effectiveness of different genres of music in reducing stress from test anxiety. Blood pressure, heart rate and skin conductance will be measured to monitor the elicited physiological stress response of a cognitive examination. We hypothesize that the calmer and more relaxing genres, classical and reggae, will bring the physiological responses back toward baseline measurements faster than the genres of hard rock and electronic dance music.

Materials

Biopac Student Lab system (BSL 4 software, MP36, Biopac Systems, Inc. Goleta, CA) was used to record and analyze data. Electrodermal Activity (EDA) was recorded via the EDA transducer provided by the Biopac system (SS3LA/L, Biopac Systems, Inc. Goleta, CA). Blood pressure and heart rate were recorded using a brachial cuff (BP791IT, Omron Healthcare, INC. Lake Forest, IL). Additional information on utilization of the equipment was gathered from Biopac Systems, Inc Student manual (Biopac Systems Inc. ISO 9001:2008).

Using Serato DJ Software, a 9 minute audio clip was created using four songs of distinct musical genres. One minute of each song was used, from the 30 second mark to the 90 second mark, creating four “subclips.” The order of subclips was randomized five times to create five
different versions of the audio clips, Table 1. Each clip was composed of the same four songs, including: “Moonlight Sonata” by Beethoven, “Chicken Soup” by Skrillex, “TNT” by ACDC, and “Three Little Birds” by Bob Marley and the Wailers. The genres represented by these songs are classical, electronic dance music, hard rock, and reggae, respectively. One minute increments of silence were played before the first subclip, after each subsequent subclip, and at cessation of the audio clip.

A high school math test consisting of basic algebraic equations and word problems from the Varsity Tutors website, titled, “High School Math Test #2,” was used as a stressful cognitive stimulus.

Methods

Study Design

Participants were selected from the Spring 2018 Physiology 435 course at University of Wisconsin-Madison. The students were subjected to a math assessment while listening to an audio clip of four songs of different genres. The physiological responses of heart rate, blood pressure, and EDA were recorded, while the subject was simultaneously taking the math test and listening to the audio clip. Consent forms were given to each participant and were completed prior to the beginning of the study.

Heart Rate & Blood Pressure

Blood pressure (mmHg) and heart beat (bpm) were measured with an Omron 10 series plus device. The ComFit Cuff was wrapped around the bare skin of the participant’s dominant upper arm, with the cuff edge about ½ inch above the elbow. Both measurements were recorded at one minute intervals and manually entered in a Microsoft Excel spreadsheet.
Effects of Different Auditory Stimulation on Physiological Stress Response

Electrodermal Activity (EDA)

Electrodermal activity was measured with an EDA transducer, with disposable electrodes placed on the subjects’ fingers. The EDA was pre-coated with isotonic GEL 101. The red lead was positioned over the pads of the participant’s index and middle finger, and then velcroed in place. This measurement was recorded with the Biopac System.

Procedure

Each participant was given a pair of headphones, a piece of scratch paper, and a pencil. The math assessment was opened and participants were told to press begin when ready. Upon starting the math assessment, the investigator played the audio clip and began data collection. A minute of silence started the audio clip so that baseline measurements could be obtained. One minute interludes of silence were placed after each genre of music, in order to allow the participant’s physiological variables to return back to their resting state. The participant was randomly assigned one of the five audio clip versions each comprising of one minute sound clips of each musical genre. The audio clip versions each contained a unique ordering of the hard rock, reggae, classical, and EDM sub-clips. Once the audio clip ended, the investigator informed the participant to stop the math assessment. The procedure is further outlined in Figure 1.

Data Analysis

Blood pressure data was measured and recorded in the final ten seconds of each silent and music subclip for every participant. The mean blood pressure was then determined for both the silent portions and music portions of each audio clip using the equation: Mean Blood Pressure = (2(diastolic value) + (systolic value))/3). The mean blood pressure baseline data recorded near the end of the silent minute was subtracted from the mean blood pressure value recorded in the last ten seconds of each subclip to determine how the participant's blood pressure
changed while listening to the various genres of music. The differences calculated in blood pressure from each participant were then averaged. This average was compared to the various genres of music.

Heart rate data was recorded in beats per minute in the final ten seconds of each subclip and silent interlude for every participant. The baseline pulse data that was collected during the silence before the subclip was then subtracted from the data collected in the final ten seconds of each subclip to determine how heart rate changed between the participant’s resting rate and while listening to various types of music. The differences calculated from each participant were then averaged and compared for each genre of music.

Electrodermal averages for the last 30 seconds of each genre’s song was calculated. The average values were then compared with the average baseline data taken during the last 30 seconds of each silent period preceding each genre’s song. The difference between the averages for each participant was used to determine the overall change EDA for each musical genre.

ANOVA statistical analyses were used to compare changes between baseline and genre measurements in blood pressure, heart rate, and EDA. An alpha value of 0.05 was deemed significant in this experiment.

**Positive Control**

The investigators of this study were utilized as subjects of the positive control. The positive controls had their blood pressure, heart rate, and EDA recorded for one minute under a silent condition and for one subsequent minute while listening to a metronome audio clip in 4/4 time at 90 beats per minute. A metronome was used to most accurately confirm that listening to sound will induce physiological changes in heartbeat, blood pressure and EDA.

**Negative Control**
The physiological baseline measurements of heart rate, blood pressure and EDA were taken during the first minute of silence before the music began to play. This was recorded for each participant in the study.

**Results**

A total of 27 participants (16 females; 11 males), ages 18-29 years old (median age = 21) were subjected to testing. An alpha value of 0.05 was deemed significant in this experiment. The average changes in heart rate, blood pressure, and EDA are found in Table 2 with their respective p-values. All physiological measurements were found non-significant.

<table>
<thead>
<tr>
<th>Genre</th>
<th>Heart Rate (beats/minute)</th>
<th>Blood Pressure (mmHg)</th>
<th>EDA (microseimens)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical</td>
<td>0.0370</td>
<td>-0.864</td>
<td>-0.034</td>
</tr>
<tr>
<td>EDM</td>
<td>0.667</td>
<td>-3.730</td>
<td>-0.015</td>
</tr>
<tr>
<td>Hard Rock</td>
<td>2.167</td>
<td>-6.580</td>
<td>-0.012</td>
</tr>
<tr>
<td>Reggae</td>
<td>0.4091</td>
<td>-0.0455</td>
<td>0.0030</td>
</tr>
<tr>
<td>ANOVA (p-value)</td>
<td>0.816</td>
<td>0.417</td>
<td>0.525</td>
</tr>
</tbody>
</table>

Note: Significant at p < 0.05 level.

*Table 2: Average physiological change per genre and ANOVA analysis. Average heart rate, blood pressure, and EDA changes of each genre were non-significant.*
Discussion

A decrease in blood pressure was found for all musical genres when the subclips were compared to the baselines. The greatest numerical decrease occurred in the hard rock genre (-6.58 mmHg), followed by EDM (-3.73 mmHg), while the classical and reggae songs both resulted in decreases in blood pressure of less than 1 mmHg, as seen in Figure 2. However, the non-significant p-value indicates that there was no statistical difference between the musical genres in their effectiveness at decreasing blood pressure. Conversely, the average heart rate increased compared to baseline for each genre, shown in Figure 3. The greatest numerical increase in heart rate occurred in the hard rock genre (2.17 bpm). All other genres had less than one beat per minute increases. The non-significant p-value connotes that heart rate was not significantly affected by each musical genre. Furthermore, the average changes in EDA from baseline were minimal, within one delta microsiemen, for all musical genres, as illustrated in Figure 4. While the hard rock, EDM, and classical genres resulted in a decrease in EDA, the reggae song resulted in a slight increase in EDA from baseline. A non-significant p-value for EDA was also calculated, and thus musical genre showed no statistical impact.

These findings did not support our hypothesis that classical and reggae music would be more effective at decreasing stress levels when compared to the hard rock and EDM genres. However, our results do add to the existing literature which demonstrates that there is no significant difference between various musical genres and elicited physiological measures of stress. For example, Marshall et al. treated patients diagnosed with chronic stress issues with music therapy consisting of five different genres (rock, jazz, minimalism, classical, and silence) and reported no significant difference in stress reduction among the various types (Marshall et al.)
Furthermore, Alagha and Ipradijan did not find a correlation between stress reduction and listening to jazz, blues, or rock music among university students (Alagha & Ipradijan, 2017). Our results do however, counter the conclusions that some literature has made regarding musical genre and stress reduction. According to Labbé et al., participants that listened to classical or self-selected music after being exposed to a stressor demonstrated decreases in physiological stress levels, as well as, negative emotional states (Labbé et al., 2007). We found that participants listening to classical music while being exposed to a stressor demonstrated no significant change in heart rate, blood pressure, or skin conductance. In addition, a study conducted on dogs also found that physiological indications of stress were reduced for dogs which were exposed to soft rock and reggae musical genres (Bowman et al., 2017). We discovered that hard rock actually greatly decreased blood pressure and slightly increased heart rate, whereas reggae did not significantly change heart rate, blood pressure, or skin conductance. Therefore, the conflicting findings of previous literature and our data make it difficult to determine whether certain genres of music are more effective than others in reducing stress levels in the general population. Perhaps the answer aligns with the findings of Chang et al., which suggested that musical genres elicit different effects on each individual, based on their like, dislike, or familiarity with the music, therefore, each person has unique needs for stress-relieving music (Change et al., 2016). Further studies could explore how personalized selections for stress-reducing music actually alters physiological stress indicators, such as heart rate, blood pressure, and EDA.
There were several limitations to our study that may have impacted our results, including sample size, cognitive assessment, and imprecise machinery. The sample size of 27 subjects may not adequately represent the 18-29 age group’s physiological reactions to stress when listening to music. Though the subject number exceeded project requirements, the considerable range in measurements of this smaller group contributed to statistically low confidence and larger p-values. In addition, the administered math exam could have falsely represented unified stress among participants, depending on their mathematical skill level and comfortability. This implies that certain musical genres may have helped relax students who found the exam stressful, while had little effect in those who did not find it stressful. Furthermore, repeated mechanical errors in the Omron cuff used to measure heart rate and blood pressure, led to decreased data collection. Omitting heart rate or blood pressure data for any subclip that an error occurred in decreased the sample size analysis and potentially compromised statistical significance. Our study did not find statistically significant results, however, this loss of data points underpowered our data and may have prevented us from finding potentially significant conclusions.

Although this study did not find any statistical significance on the physiological variables of heart rate, blood pressure, and EDA when listening to different genres of music, we find the aim of this study to be important to college students. The most accurate data of student habits and their effects on academic success has always been a topic of priority. With both increasing accessibility to music and students increased use of music while studying, further examination of the relationship is necessary to determine optimal performance. Further exploration of this topic may delve into possible differences in how males and females are affected by various musical genres or how the volume or key of the music listened to impacts physiological stress levels,
rather than a specific musical genre. Such investigations could shed light on music’s contested potential to aid students with acute test anxiety and improve exam outcomes.

References


Acknowledgments

We would like to thank Dr. Lokuta, the TA’s, the peer learning advisors, and all of the participants for their help in completing our study.

Appendix 1: Tables and Figures

Table 1: Genre sequence of audio clips. This table highlights distinct ordering of audio clip versions in chronological order. Abbreviations are defined as: C: Classical, EDM: Electronic Dance Music, HR: Hard Rock, and R: Reggae.

<table>
<thead>
<tr>
<th>Audio Clip Version</th>
<th>Order of Genre Played</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>HR EDM C R</td>
</tr>
<tr>
<td>A2</td>
<td>EDM HR R C</td>
</tr>
<tr>
<td>A3</td>
<td>C EDM R HR</td>
</tr>
<tr>
<td>A4</td>
<td>R C EDM HR</td>
</tr>
<tr>
<td>A5</td>
<td>C R HR EDM</td>
</tr>
</tbody>
</table>

Figure 1: Chronological outline of experimental procedure.
Figure 2: The average change in blood pressure in mmHg for each musical genre.

Figure 3: The average change in heart rate in beats per minute for each musical genre.
Figure 4: The average change in skin conductance in delta microsiemens for each musical genre.