The Effects of Music Genre on Physiological Measures of Stress from Arithmetic Testing

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Abstract

Stress is a common and unavoidable phenomenon in humans due to the numerous pressures and obligations that are experienced on a regular basis. Although stress is a necessary physiological mechanism, excess stress can lead to adverse outcomes, thereby decreasing an individual's overall quality of life. Countless methods are utilized by people all over the world in attempt to overcome elevated levels of stress. Among these methods is listening to music. This study looked at the effectiveness of high versus low arousal music, in the forms of heavy metal and classical, on the physiological measures of stress. The significance of this study is to devise methods of alleviating high stress levels caused by academia in college students, with the potential to be applied to other populations as well. It was hypothesized that following a stress-inducing task, low arousal music would lower stress levels below or near baseline, high arousal music would keep stress levels raised above baseline, and the absence of music would allow for a slower regression back to baseline as compared to low arousal music. Stress levels were measured using heart rate, blood pressure, and electrodermal activity, and it was found that neither classical nor heavy metal music significantly affect stress levels. However, due to the large number of limitations associated with this study, the results are inconclusive.

Introduction

All individuals experience routine amounts of stress throughout their lives as a result of pressure from their work, education, family, and daily responsibilities. College students experience immense amounts of stress due to their rigorous workload, frequent examinations, and assignment deadlines. A survey done by The Anxiety and Depression Association of America revealed that approximately 80 percent of college students frequently experience daily stress (ADAA 2015). Stress is defined as the measurable physiological changes that occur in the body following a negative experience (Baum 1990). The "Stress in America" survey is utilized by the American Psychological Association in order to examine the impact of stress on the health and wellbeing of adults in the United States. The survey found that most adults report that stress has a negative impact on their physical and mental health (APA 2015). Some stress is necessary for normal survival and bodily processes; however, excess stress can lead to adverse outcomes.

Test anxiety is a specific type of stress that greatly impacts college students. It is associated with feelings of nervousness and apprehension prior to and/or during an exam and can trigger a multitude of physiological responses, including increased blood pressure, rapid heart rate, sweating, dryness of the mouth, nausea, dizziness, hyperventilation, restlessness, tremors, and fatigue (Reteguiz 2006). High levels of stress can negatively impact academic performance, mental health, and physical homeostasis (Schneiderman et al. 2005). A study conducted on 376 randomly selected undergraduate students through 15 degree programs at the Universiti Putra Malaysia (UPM) shows evidence of a significant negative relationship between stress levels and academic achievement (Elias et al. 2011). Apart from detrimental impacts on mental health and academic performance, elevated levels of stress over a prolonged period of time can have a multitude of physiologic complications, including increased risk of infection due to immunosuppression, high blood pressure and increased heart rate, osteoporosis, and muscle weakness (Tsigos and Chrousos 2002).

There are some scientifically supported ways in which students can attempt to address their elevated stress levels. A cross-sectional study on 388 medical students sought to determine the test anxiety they experience and assess the measures they used to reduce it (Hasnain 2012). Researchers found high levels of exam anxiety and concluded that the most frequent measures taken by students to overcome their stressors were listening to music, self-motivation, and sleep or relaxation (Hasnain 2012).

Listening to music while studying is a common way students alleviate pre-existing stress. Music is closely correlated with emotion and has been shown to reduce anxiety, and thus, is viewed as an effective, non-invasive intervention for stress (Jiang et. al 2016). A 2002 study that evaluated the effects of different types of music on perceived and physiological measures of stress found that classical music, defined as a low arousal stimulus, was more effective than heavy metal and hard rock music, defined as a high arousal stimuli, at reducing stress (Burns et. al 2002).

The genre of music selected for testing may play a significant role in the resulting stress response. A study on the effect of music on blood pressure recovery after stress found that participants exposed to classical music had significantly lower blood pressure levels following the stressor than those in the no-music group (Chafin et. al 2004). Furthermore, it was observed that other styles of music were no better than silence at reducing blood pressure (Chafin et. al 2004). This information may be useful in shaping the type of music students listen to while they study and attempt to reduce their daily levels of stress. Therefore, the purpose of this study is to explore the ways in which low versus high arousal music succeeding a stressful event (i.e. an arithmetic test) impact physiological indicators of stress, such as heart rate, blood pressure, and skin conductivity.

Ultimately, it was hypothesized that the presence of low arousal music (classical) would lower stress and bring it below or near baseline levels, high arousal music (heavy metal) would keep stress levels higher than baseline, and the absence of music (control) would allow for a slower regression to baseline over time as compared to low arousal music. Uncovering the conditions under which stress is most reduced for individuals following a stressor could meaningfully aid in stress alleviation. Academic stressors play a significant role in the mental and physical health of college students, thus, deciphering mechanisms to alleviate said stress would be beneficial to psychological and physiological well-being.

Material and Methods

Materials

- BIOPAC Student Lab Manual (P/N MANBSL4/45) Manufacturer: BIOPAC Systems, Inc. (Goleta, CA 93117)
- Biopac Student Lab System: BSL 4.0 software, MP36 hardware (P/N MP36U-W) Manufacturer: BIOPAC Systems, Inc. (Goleta, CA 93117)
- Computer system (Windows 7) Manufacturer: Microsoft Corporation (Redmond, WA)
- OMRON 10 series + blood pressure monitor (P/N BP791IT) Manufacturer: OMRON Corporation (Hoffman Estates, IL)

- BIOPAC EDA Transducer (P/N SS3LA/L) Manufacturer: BIOPAC Systems, Inc. (Goleta, CA 93117)
- BIOPAC Electrode gel (P/N GEL101) Manufacturer: BIOPAC Systems, Inc. (Goleta, CA 93117)
- Lab table for Supine position
- Apple iPhone 7 (A1778) Manufacturer: Foxconn Technology Group (New Taipei, Taiwan)
- Music:
  - Classical - “Distant Sunset,” Calm Piano Music, Ivory Dreams Album, by Sean Beeson 2004
  - Heavy metal - “Fight Song Heavy Metal Instrumental” 2013 by William Barnes
- Arithmetic Test (created by researchers, attached with figures)
- Writing Utensil
- Random Number Generator (Random.org)
- Statistical Analysis via an online generator: http://turner.faculty.swau.edu/mathematics/math241/materials/anova/

Participants

The sample consisted of 21 undergraduate students at the University of Wisconsin-Madison enrolled in Physiology 435. There were 8 female participants and 13 male participants within the ages of 20 and 23. A total of 7 participants were included in the control group and 7 participants were included in each experimental group. As these students were recruited, they were assigned to a random group based on a random number generator to ensure internal validity. They were then assigned a subject ID to ensure privacy of their information.

The arithmetic test was designed to be challenging enough to induce stress, while simultaneously being feasible enough to maintain motivation in test subjects to continue. Moreover, the test was intended to challenge participants of varied levels of math competency; thus it included a multitude of problems, ranging from elementary arithmetic to basic calculus.

Procedure

A consent form was given to participants to sign prior to data collection. Participants were informed of the tasks that would be involved during the experiment and were told that participation is voluntary. Further, they were told that if they were experiencing any discomfort at any point during the experiment, they should inform the researcher right away. In addition, participants were given a questionnaire regarding age, sex, preferred music genre, highest level of math taken, and any other information they wanted to provide. The questionnaire allowed the investigators to determine whether certain trends in data correlated with the participants' responses.

Prior to experimentation, participants were assigned to one of three experimental groups: negative control with no music (group A), experimental group with classical music (group C), and experimental group with metal music (group B). Group assignment was determined randomly through a random number generator. For each experimental group, a set playlist was created in order to keep the experimental variable constant. Participants' baseline values of heart rate, blood pressure, and skin conductance were taken prior to the mathematical exam. Prior to any experimentation, all of the equipment was tested on the investigators as a positive control in order to confirm the equipment was working properly and determine whether noticeable changes in physiological conditions throughout the course of the experiment were detectable. These measurements were taken using a pressure cuff on each participant's left arm and a BIOPAC EDA system on each participant's non-dominant index and middle fingers. EDA was recorded continuously from start to finish (figure 5), and blood pressure and heart rate were recorded before the math test was administered, after the math test, and after listening to music for 5 minutes. The 5 minutes of time was chosen arbitrarily in order to provide adequate time for researchers to collect data as well as acquire physiological responses from the test subjects. Participants were told to take a math test where they would complete as many problems as possible in 3 minutes. The 3 minutes of time allotted for taking the math test was intended to be long enough to induce a stress response and short enough to maintain stress levels and collect accurate readings. The arithmetic test was designed to be challenging enough to induce stress, while simultaneously being feasible enough to maintain motivation in test subjects to continue. Moreover, the test was intended to challenge participants of varied levels of math competency; thus it included a multitude of problems, ranging from elementary arithmetic to basic calculus. The math test was incentivized with a $10 Starbucks gift card for correct and full completion by the participant. Providing an incentive increased the chance that the math test would induce stress on the participants, since they were more likely to be more motivated to perform well. At least one experimenter stayed with the participants during the full math test to ensure they continued to do their assigned activity and did not cheat. After the two minutes of testing, participants' blood pressure, heart rate, and skin conductance were recorded. Then, participants were given a song within a predetermined genre to listen to for 5 minutes. After 5 minutes, blood pressure and heart rate were recorded again and heart rate and EDA recording was stopped.

The control group was administered the same math test, but was given no music to listen to after the test. Instead, participants would wait for 5 minutes after the test. Skin conductance was continuously recorded from before the math test (baseline) until 5 minutes after the math test had passed. Blood pressure and heart rate were recorded before the math test, after the math test, and after the 5 minutes had passed.

Data Analysis

Our data for each participant was compared to the baseline values in order to determine whether the participants who listened to music exhibited any major physiological differences in their induced stress levels as compared to the controls. Significance was set at $p < 0.05$. The findings were analyzed using a one-way ANOVA, which tests for statistical significance between the means of two or more independent groups.

Results

Control

Changes in heart rate over the course of testing of the control group were evaluated by a one-way ANOVA to test for the significance in changes in heart rate following the arithmetic test and after a waiting period of five minutes. The p-value for this evaluation was less than 0.05 (0.0239), indicating statistical significance.

The mean percent change in heart rate from the end of the arithmetic test to heart rate at the end of the five minute waiting period was -10.76%. The mean percent change in heart rate from baseline to after the five minute waiting period was +10.19%. The mean percent change in EDA measurement from the end of the arithmetic test to EDA measurement after the five minute waiting period was +4.72%. The mean percent change in baseline EDA measurement to after the five minute waiting period was +29.19%. The mean percent change in mean arterial pressure (MAP) from the end of the arithmetic test to after the five minute waiting period was -4.84%. The mean percent change in baseline MAP to after the five minute waiting period was -6.42%.

Classical Music
The mean percent change in heart rate from the end of the arithmetic test to heart rate after listening to music in the classical music group was +5.10%. The mean percent change in heart rate from baseline to after listening to music in this group was +17.98%. The mean percent change in EDA measurement from the end of the arithmetic test to EDA measurement after listening to music was +1.64%. The mean percent change in baseline EDA measurement to after listening to music was +14.63%. The mean percent change in MAP from the end of the arithmetic test to MAP after listening to music was -5.20%. The mean percent change in baseline MAP to after listening to music was +3.40%.

Heavy Metal Music
The mean percent change in heart rate from the end of the arithmetic test to heart rate after listening to music in the heavy metal group was -3.73%. The mean percent change in heart rate from baseline to after listening to music in this group was +1.43 percent. The mean percent change in EDA measurement from the end of the arithmetic test to EDA measurement after listening to music was -0.129%. The mean percent change in baseline EDA measurement to after listening to music was +34.54%. The mean percent change in MAP from the end of the arithmetic test to MAP after listening to music was +0.85%. The mean percent change in baseline MAP to after listening to music was -1.94%.

Control versus Classical
A one-way ANOVA was used to evaluate the significance of the difference between the control and classical music groups. The difference in mean percent change in heart rate from after the arithmetic test to the final measurement had a p value of 0.2576. The difference in mean percent change in heart rate from baseline to the final measurement had a p value of 0.8399. The difference in mean percent change in EDA measurement from after the arithmetic test to the final measurement had a p value of 0.9580. The difference in mean percent change in EDA measurement from baseline to the final measurement had a p value of 0.9829. The difference in mean percent change in MAP from after the arithmetic test to the final measurement had a p value of 0.9971. The difference in mean percent change in MAP from baseline to the final measurement had a p value of 0.2863.

Control versus Heavy Metal
A one-way ANOVA was used to evaluate the significance of the difference between the control and heavy metal groups. The difference in mean percent change in heart rate from after the arithmetic test to the final measurement had a p value of 0.6542. The difference in mean percent change in heart rate from baseline to the final measurement had a p value of 0.7012. The difference in mean percent change in EDA measurement from after the arithmetic test to the final measurement had a p value of 0.9036. The difference in mean percent change in EDA measurement from baseline to the final measurement had a p value of 0.9829. The difference in

mean percent change in MAP from after the arithmetic test to the final measurement had a p value of 0.5341. The difference in mean percent change in MAP from baseline to the final measurement had a p value of 0.6159.

Classical vs Heavy Metal
A one-way ANOVA was used to evaluate the significance of the difference between the classical and heavy metal groups. The difference in mean percent change in heart rate after the arithmetic test to the final measurement had a p value of 0.5848. The difference in mean percent change in heart rate from baseline to the final measurement had a p value of 0.4711. The difference in mean percent change in EDA measurement from after the arithmetic test to the final measurement had a p value of 0.8945. The difference in mean percent change in EDA measurement from baseline to the final measurement had a p value of 0.7083. The difference in mean percent change in MAP from after the arithmetic test to the final measurement had a p value of 0.3336. The difference in mean percent change in MAP from baseline to the final measurement had a p value of 0.6159.

Discussion

Previous studies on the relationship between stress and various genres of music have shown that listening to music impacts the psychobiological stress system (Thoma et al. 2013). Other studies have been conducted to determine whether the genre of music has an impact on the change in physiological measures. For example, Elise Labbé, Nicholas Schmidt, Jonathan Babin, and Martha Pharr (2007) found that classical and self-selected music more significantly reduced physiological stress levels when compared to heavy metal music. However, this study herein appears to be the first that utilizes an academic subject-based test as the stressor preceding exposure to various music genres. Nevertheless, it was expected that similar results would be obtained in comparison with previous studies.

In this study, 21 UW-Madison undergraduates were randomly recruited to test whether music genre impacted their stress levels following a stressor (an arithmetic test). It was hypothesized that classical music would be more effective in reducing stress levels and bringing them back to or near baseline than heavy metal music. Measures used to determine stress levels throughout the experiment included heart rate, blood pressure, and EDA. It was expected that the classical music group, Group C, would experience reduced relative final readings in heart rate, blood pressure, and skin conductivity. Furthermore, it was anticipated that heavy metal would keep stress levels comparatively high and, thus, participants would maintain elevated values for heart rate, blood pressure, and EDA.

Overall, the math test and time allotted was significantly effective ($p<0.02$) in inducing stress in test subjects regardless of math level and proficiency (Figure 1). We expected arithmetic comfort level to be a limitation, but it was not. However, following experimentation and analysis, it was deduced that classical music may not be as effective as anticipated at reducing stress levels.

Ultimately, we do not have enough conclusive data to confidently confirm whether our hypothesis was proven or disproven. However, according to the data we have collected, it appears as though heavy metal music is a more effective method of reducing heart rate and EDA than classical music (figures 2 and 3), while classical music is more effective at reducing blood pressure (figure 4), which would suggest that the hypothesis was incorrect for 2 out of 3 variables.

Although it was insignificant, heavy metal performed better than classical in reducing certain measures of stress (figure 2), which was an unexpected finding. There existed a wide spectrum of preferred music genres across our test subject, ranging from alternative to pop/hip hop. The music preferences were not closely associated with classical or heavy metal, so perhaps an intermediate song choice may have been most effective at reducing stress.

The lack of significant results could be attributed to a number of experimental caveats. A large pitfall of the experiment was the transition time in between the end of the subjects taking the math test to the start of the subjects listening to their respective songs. The transition should have been immediate; however, the subjects had to get their heart rate and blood pressure measurements taken as well as put headphones in their ears right at the conclusion of the math test, which took about one minute. We would have acquired more accurate readings had the subjects taken the math test with headphones already in their ears, followed by the immediate playing of the song at the conclusion of the 3-minute test. Additionally, future testing should utilize noise-cancelling headphones to ensure that no background noise blends in with the music. Likewise, the control condition in future studies should also be given noise cancelling headphones in order to better control for variations in background conversations in the lab room.

Additional limitations of this study pertain to the extremely small sample size and highly isolated population, as data on a group of college students all enrolled in the same class may not be applicable to the general public. Moreover, the data may have not aligned with expectations due to the arithmetic test's varied ability to induce stress in different individuals, as well as individuals' music preferences, length of the music exposure, and the inability of a Starbucks giftcard to act as an adequate motivator for serious performance on the test. Another concern is that heart rate, blood pressure, and electrodermal activity do not necessarily increase or decrease in unison, thus making it difficult to determine whether or not a person was actually stressed. Some of data may have been skewed as a result of students' exam schedule and workload.

The broad understanding of this topic underlines the complex psychological and physiological mechanisms of stress. This study also provides insight into the intricate stress response as it varies widely amongst different individuals, presents itself in a myriad of ways, and can arise from a multitude of stimuli. Although the findings do not parallel those of others in the field, they make sense because the study was limited in terms of funding, time, and number of participants. The compilation of the findings in the aforementioned studies in juxtaposition with the results of this study led to the conclusion that personal music preference, a variable that was not included in this study, may be the most effective at reducing physiological stress levels.

Future research conducted on this topic should address the aforementioned limitations as well as utilize a more effective and wide-reaching method of stress induction. Ultimately, additional findings would aid in determining the best form of stress reduction and relief for students. In the future, universities could have the potential to implement necessary stress reduction methods and educate students on the best practices to decrease overall stress. Further research may also be applied to larger populations beyond college students, such as working individuals, people with mental illness, and people suffering from chronic stress or anxiety. Finally, further research of this sort could be conducted to determine whether it’s more useful to listen to music before encountering a potential stressor or after already being stressed.

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Tables

	Initial To Final EDA	Initial to Final HR	Initial to Final MAP	After to final EDA	After to Final HR	After to Final MAP
Control v Classical	0.9829	0.8399	0.2863	0.9580	0.2576	0.9971
Classical v heavy metal	0.7083	0.4711	0.4850	0.8945	0.5848	0.3336
Heavy Metal v control	0.9829	0.7012	0.6159	0.9036	0.6542	0.5341

Table 1: Table of P Values from Analysis of Variance through One-way Anova across test groups.

Figures

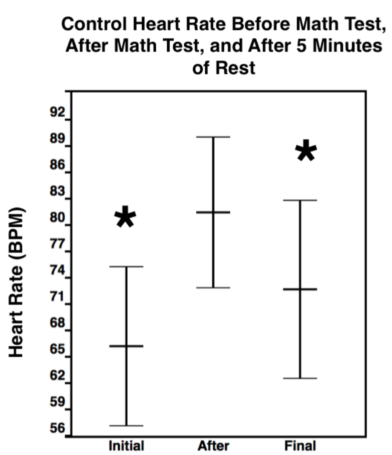

Figure 1: Graph of initial heart rate, heart rate after math test, and final heart rate in Control Group was statistically significant ($p < 0.0239$). This shows that stress was effectively induced with the math test and brought back down after rest.

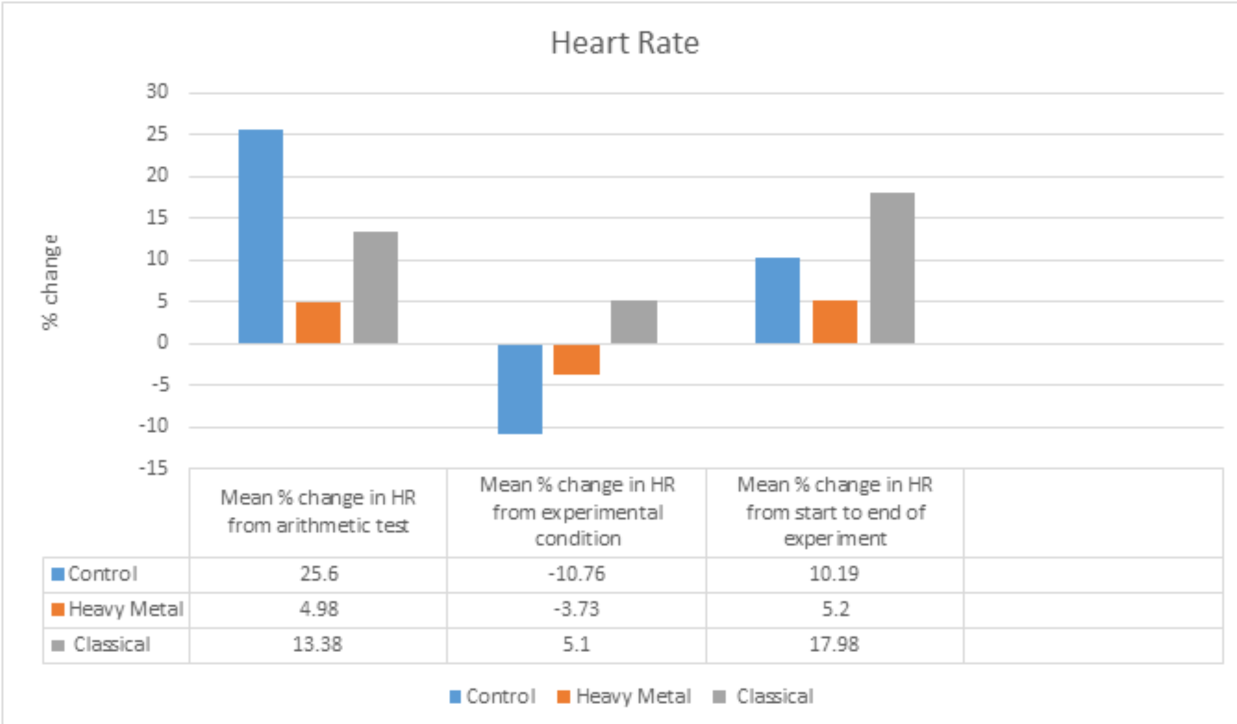

Figure 2: Graphs of mean percent change in Heart Rate (beats per minute, BPM) from arithmetic test, experimental condition (music or rest for 5 minutes), and from start to end (initial to final reading) across control and experimental groups. All were in significant, with $p > 0.05$.

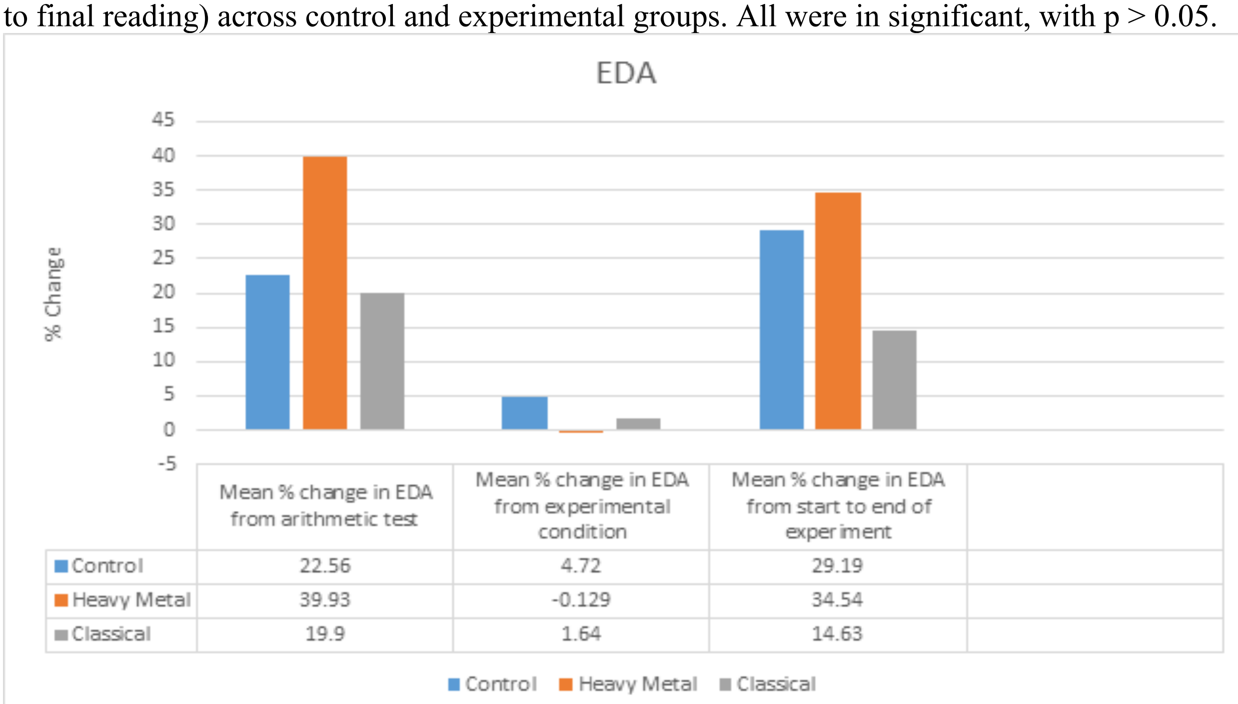

Figure 3: Graphs of mean percent change in EDA (microsiemen) from arithmetic test, experimental condition (music or rest for 5 minutes), and from start to end (initial to final reading) across control and experimental groups. All were in significant, with $p > 0.05$.

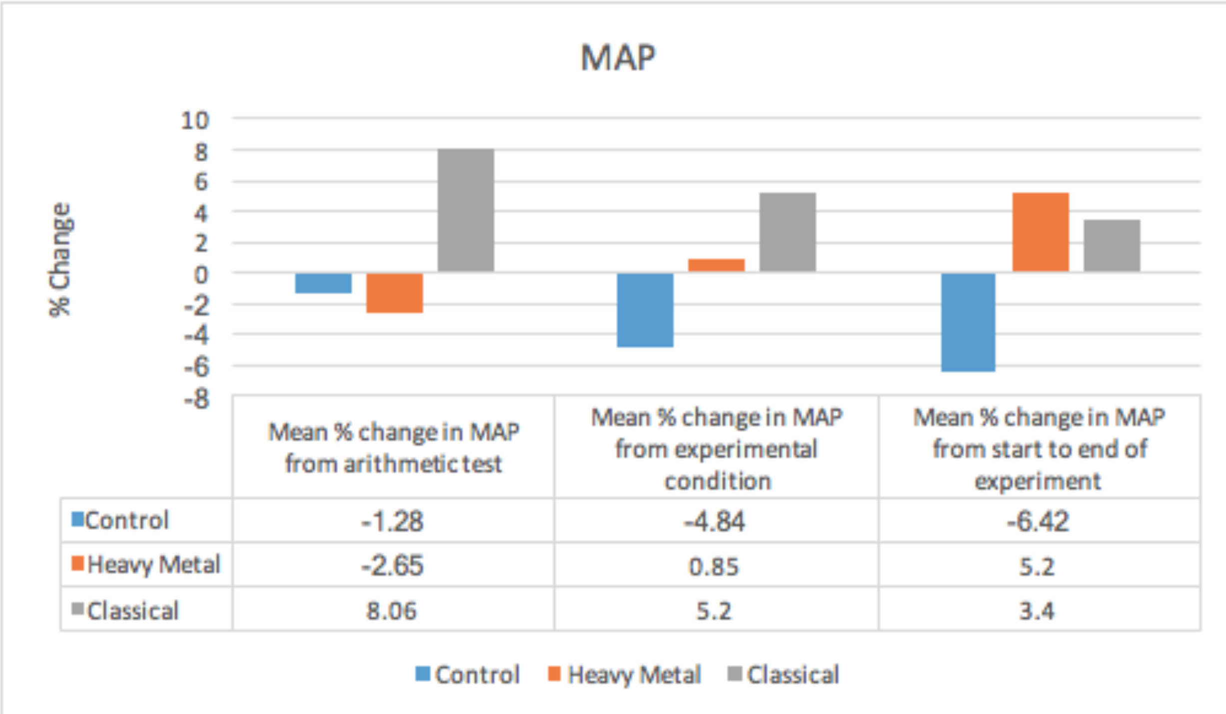

Figure 4: Graphs of mean arterial pressure (MAP) in mmHg from arithmetic test, experimental condition (music or rest for 5 minutes), and from start to end (initial to final reading) across control and experimental groups. All were insignificant, with p > 0.05.

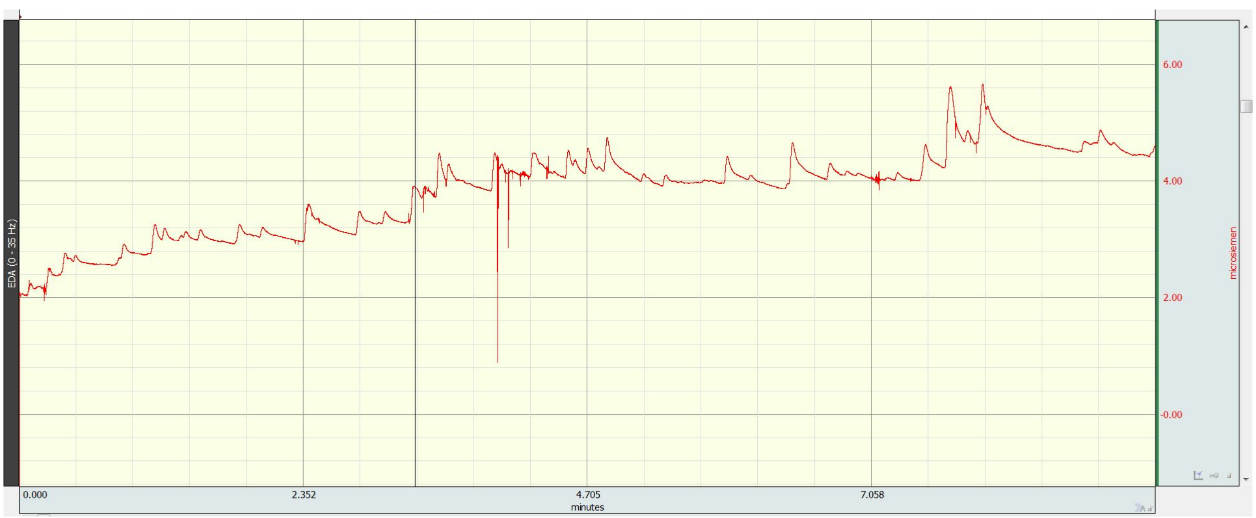

Figure 5: Sample Electrodermal Activity (EDA) measurement reading.

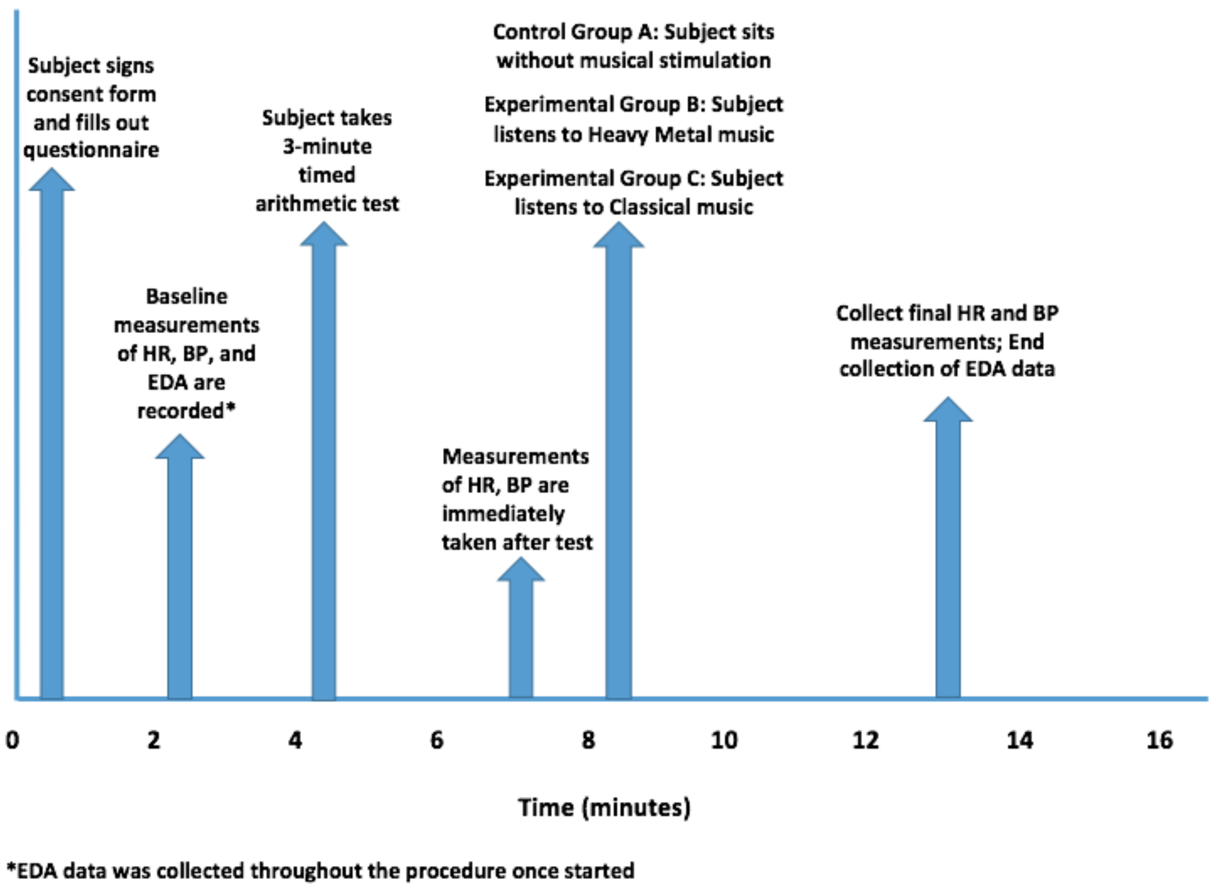

Figure 6: Experimental Timeline. Each participant followed this procedure, lasting a total of ~15 minutes.