**How Music Genre Affects Memory Retention & Physiological Indicators of Stress**

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**Abstract**

Understanding which genre of music helps students attain the right amount of stress to perform at their best capability is essential to their success in school. Different genres of music have been suggested to alter physiological indicators of stress and the ability to recall information, yet it is debated as to which genre produces positive effects associated with stress and memory. This study investigated the difference between rap and classical music on the physiological stress response using heart rate, respiration rate, and blood pressure, as well as the memory retention abilities of each study participant. Respiration rate (RR), heart rate (HR), and blood pressure (BP) were measured while participants filled out a survey with no music as a baseline, followed by a written exam with rap or classical music playing throughout. A follow-up retention test was conducted two weeks later where the same written exam was administered over the same amount of allotted time, with no music playing. We hypothesized that rap music would increase the physiological indicators of stress, while classical music would decrease the indicators of stress. In addition, we hypothesized that participants who listened to classical music, in comparison to rap music, while performing the first written exam would have better scores and memory retention on the follow-up exam. Our results concluded no significant difference between the two test groups in any physiological variable of stress. In terms of first and second exam performance or improvement scores, there was no statistically significant difference between the rap group compared with the classical group. However, both groups did have significant memory retention improvement scores. These conclusions do not support our hypothesis. Further studies could test if different genres of music have an effect on any of the

variables, if studying with music versus without music has an effect, or if getting a more varied range of participants could impact the results.

**Introduction**

The effects of different background music on various aspects of our lives is debated within the professional and social worlds. The value of music transcends all cultures, countries, and peoples all around the globe. Although musical preferences during leisure time vary from person to person, it has been hypothesized that certain types of music can put us in a mindset well adapted to carrying out specific tasks such as doing homework, memorizing, relaxing, and more (Chanda and Levitin, 2013). This means that listening to various types of music could potentially enhance academic success in school, relieve stress, and provide other benefits (Cabanac et al., 2013, Terry et al., 2012, North et al., 2004). The opportunities are endless, yet there is a large gap of knowledge as to what kind of music is most beneficial to our daily lives. This study explores the unknown comparison between the rap and classical genres and their effects on our basic and stressed physiology and simple memory retention.

Many studies over the years have been able to pinpoint the section of the brain that is stimulated by various aspects of music such as rhythm, pitch, melody, etc. (Warren, 1999, Peretz, 1990). When a song passes into our cochlea, it enters a hierarchy leading from preprocessing to processing mechanisms within the brain. The preprocessing stages involve the transformation of the music in the auditory brainstem, emotional recognition in the thalamus, amygdala, and medial orbitofrontal cortex, and extraction of specific musical properties such as rhythm in the auditory cortex. Thereafter, the processing stage begins where the musical features are sent to the auditory sensory memory. The music is then recognized and analyzed throughout

multiple branches in the brain, in which certain aspects of the music of its meaning are differentiated. Most notably in the mechanisms of musical processing is the suggestion that within the limbic system, music has the ability to provoke emotions and memories (Jancke, 2008). Additionally, there has also been research suggesting the learning and memory acquired from music may be due to the physiological responses of the body (Landreth, 1974).

Music has the ability to significantly change our physiological status depending on the genre and type of music. A study done by Trappe and Voit on the cardiovascular effects of music concluded that participants listening to a piece by Mozart had lowered blood pressure and heart rate in comparison to listening to ABBA, a Swedish pop group (2016). Additionally, another study done showed that classical music relaxed and reduced stress in kennelled dogs (Bowman et al., 2017). In contrast, most of the literature on rap music effects on physiology have concluded that rap has a tendency to increase blood pressure, heart rate, and lessen relaxation (Bernardi et al., 2006).

Blood pressure, heart rate, and respiration rate are significant measures of stress within the study participants, although they are not direct. In one study investigating the stressful effects of computer work on blood pressure and heart rate variability, it was found that in more mentally stressed situations, heart rate and blood pressure were significantly increased (Hjortskov, 2004). Breathing patterns have also been found to be a satisfactory physiological index to measure stress and anxiety levels. Under conditions of high stress, respiration rate increases and an irregular pattern of breathing can occur (Grossman, 1983). Additionally, increased levels of stress have been shown to hamper memory retention in men (Kulmann et al., 2005), as well as women (Schwabe and Wolf, 2010). Putting everything together, this suggests that the type of

music that students select to study with may alter stress level and in turn alter their performance on exams.

Furthermore, there is evidence that the genre of music listened to has various effects on memory retention and learning tasks. In a study done by Bugtar and Carden, their results concluded that participants listening to classical music scored better on a simple memory task than participants listening to rap music (2012). Additionally, multiple studies have been done and popularized as the "Mozart Effect," claiming that listening to Mozart for a given period of time may increase your spatial reasoning, but not your general intelligence (Jenkins, 2001). Although there is limited research of the effects of rap music on memory, there are some suggestions that rap music may allow you to more effectively learn English and other languages (Kao and Oxford, 2014).

The goal of this study was to determine the various effects between classical and rap music by measuring physiological data (blood pressure, heart rate, and respiration rate) as well as memory retention of trivia and simple math and english questions. Our hypothesis of this study was that listening to classical music would lead to decreased heart rate, respiration rate, and blood pressure, indicating that the test subject was calm and relaxed while doing the written exam; whereas listening to rap music would increase their heart rate, respiration rate, and blood pressure. In another assessment two weeks later, we hypothesized that the classical music subjects would retain the exam information better than the rap music subjects. In the bigger picture of our study, we hoped to find some hints to the musical genre we should encourage others to listen to in order to perform at their best ability. Although this is just a start to a larger

and more involved theory, the findings of this study could allow for future experiments to build off of the realm of musical effects on the mind and body.

## Materials

Heart rate (HR), respiration rate (RR), and systolic and diastolic blood pressure (BP) were all examined using three different measurement devices. Heart rate was measured using a Biopac electrode lead set (Model: SS2L, Biopac Systems, Inc. Goleta, CA) and Biopac disposable electrodes (Model: EL503, Biopac Systems, Inc. Goleta, CA). A respiratory belt (Model: SS5LB, Biopac Systems, Inc. Goleta, CA) was used to measure respiration rate in breaths per minute. Lastly, blood pressure was measured using an Omron automatic blood pressure monitor and brachial cuff (Model: BP791IT, Omron Healthcare, Inc. Lake Forest, IL). Data recording and analysis was conducted using the Biopac Student Lab System (BSL 4 software, MP36, Biopac Systems, Inc. Goleta, CA). A pair of Apple headphones and a Texas Instruments TI-30X IIS calculator was given to the participant at the start of the study. Music was played while the participants were completing the worksheet given. Two music selections were chosen for the two groups of participants. The first piece was “Piano Concerto No. 21 in C Major, K, 467 “Elvira Madigan”: II. Andante” by Wolfgang Amadeus Mozart. The second piece was “Not Afraid” by Eminem. The genres represented by these two songs are classical and rap, respectively. The participants were given a maximum of 4 minutes of music playing or until he/she had completed the worksheet.

## Methods

*Participants*

Participants consisted of students from the University of Wisconsin- Madison. They were at least 18 years of age and were enrolled in Anatomy and Physiology 435. All measurements for the experiment were collected at the UW- Madison Medical Sciences Center. All participants signed a consent form stating all matters related to the study will be kept private and were made aware of any potential risks.

*Procedure*

Participants were eligible to participate in this study if they signed the consent form, were at least 18 years old, and were also enrolled in the course Anatomy and Physiology 435. There were no other specific exclusion criteria. Experimentation was conducted in a secluded room to eliminate any sort of distractions and to ensure participants could do their best in the allotted time. Two researchers entered the room to set up the equipment in order to measure heart rate, blood pressure, and respiration rate before the participant was brought in.

The equipment used were Biopac electrode lead set and Biopac disposable electrodes to measure heart rate, respiratory belt to measure respiration rate, and automatic blood pressure monitor and brachial cuff to measure systolic and diastolic blood pressure. The respiration belt was connected into channel 1 of the Biopac Student Lab System and the electrode lead output was inserted into channel 2 of the Biopac Student Lab System. The blood pressure monitor was connected to an outlet. The electrodes were attached to each participant's dominant arm and both ankles, and the brachial cuff was attached to the nondominant arm. The respiratory belt was wrapped around each participant's chest. The participants were then instructed to sit with a straight back, both feet flat on the ground, and the non-dominant arm resting on the thigh.

Once setup was complete, the participants were given a survey consisting of simple personal information questions such as name, email, and age (Figure 3). This served as our negative control and their physiological measures were taken as a baseline. The point of this was to ensure they had low stress levels during the survey, as well as to make sure the Biopac system was operating correctly before actual testing began. There was no music being played during this time. Their blood pressure was then taken at the end of the survey.

Afterwards, participants were given a worksheet which consisted of algebra problems, making correct use of English language terms, and basic trivia questions (Figure 4). Along with that, each participant was given a pair of headphones, a piece of scratch paper, a pencil, and a scientific calculator. Either "Piano Concerto No. 21 in C Major, K, 467 "Elvira Madigan": II. Andante" by Wolfgang Amadeus Mozart or "Not Afraid" by Eminem was played to each participant through headphones only when they were working on the worksheet. Half of the subjects received the classical piece and the other half the rap music, with who received what music being determined at random.

Volunteers had 4 minutes to answer as many questions correctly as possible while measurements were being recorded. If the participant did not finish the worksheet within the 4 minutes, they were told to stop working and their answers and progress were recorded. Participants who finished the entire worksheet before 4 minutes had their completion times recorded. Regardless of their finishing time, each participant had their systolic and diastolic blood pressure taken again immediately after they stopped doing the worksheet. The test subjects were then informed that they would be tested on the worksheet content after two weeks.

Once two weeks had elapsed from the initial testing date, each subject was approached before a Wednesday Physiology 435 lecture and instructed to answer all the questions on the worksheet again for another 4 minutes. There was no music playing this time. If subjects were not present in lecture, we scheduled a time that would work for them within the same week. We measured for accuracy and memory retention on the material from the first test. Figure 1 offers a good summary of the experiment timeline.

*Data Analysis*

Following the experiment, the average heart rate and respiration rate during the negative control and the actual experiment were calculated based on the data from the Biopac Student Lab System. The blood pressure was measured once at the end of each experiment phase using an external module, and from those values Mean Arterial Blood Pressure (MAP) was determined. Averages were used to determine the subjects' overall response to the musical stimulus so as to avoid samples being unreasonably biased by an outlying result and to control for the increased time of the test compared to the baseline. Once all averages for each participant were calculated, four additional averages were calculated based on the previous values: two for the negative control/baselines of each group, one for the group listening to classical music, and one for the group listening to rap music. A paired, two-sided t-test was then conducted to compare the average baselines with that of the classical music group and the rap music group. An unpaired, two-sided t-test was used to compare the classical music group with the rap music group. These tests were used to determine if the baseline values significantly differed from the experimental values, as well as to see whether or not the genre affected the participants' vital rates. If $p < 0.05$, the results were determined to be statistically significant.

The participants' answers to the questionnaires were also recorded and compared. The questions were scored based on correctness and completeness. Incomplete or unanswered questions were marked wrong. Once every participant finished taking both the primary exam during the physiological testing and the secondary, retention exam after the two-week follow-up, the average of all the scores for each group (classical vs rap) on each of the testing days was determined. The first test score for each participant was also subtracted from their second test score, and the resulting numbers were then averaged within their group. This gave an average of the change in score from the first to the second test in both the classical and the rap groups. The averages were then compared against one another using an unpaired, two-sided t-test to determine: which music genre group had the better scores on their initial tests, which group had the better scores on the second test, and which group had the greater change in score from the first to the second tests. Each group's scores from the first to the second test were also compared using a paired, two-sided t-test. As before, if $p < 0.05$, the results were determined to be statistically significant.

*Positive Control*

Positive control tests were conducted by the group investigators to ensure the Biopac and Omron equipment worked properly. The measurements taken were for HR, RR, and systolic and diastolic BP. Each member performed jumping jacks for one minute. All measurements were taken both before and after the jumping jacks were performed.

Before performing the jumping jacks, the average HR was 84.8 beats per minute, the average RR was 15.4 breaths per minute, and the average systolic BP was 112.8 and the average diastolic BP was 81.4. After performing jumping jacks, the average HR was 112.8 beats per

minute, the average RR was 22 breaths per minute, and the average systolic BP was 127.2 while the average diastolic was 83.6. This demonstrated that the equipment was indeed working properly as quantifiable results were obtained and differences were present between the initial and the later measurements.

*Negative Control*

There was a simple survey for each participant to fill out while being connected to the measuring devices when they first entered to perform the experiment. This was done before each participant completed the worksheet with the music stimuli. This survey functioned as the negative control since the survey is easy and unstressful to fill out. This measurement was made to show relaxed and low stress levels to act as a baseline measurement without auditory stimuli. The data for this period was compared against the experimental stimulus data. Comparing these allowed us to determine the effect different music genres have on focusing while completing a harder worksheet. The difference between these two periods allowed for analysis of the impact of music stimuli on concentration.

**Results**

*Subjects characteristics*

A total of 52 subjects participated in this experiment. For all included participants, measurements of respiration and heart rate were taken while they worked on the survey and the worksheet. Blood pressure measurements were recorded after they completed the survey and worksheet.

Measurements from the survey were used as the baseline. Both paired as well as unpaired, two-sided t-tests were performed to obtain the p-values and determine the significance depending on whether we were comparing the same subjects at two different times or two different sets of subjects. The t-tests were calculated using the difference in physiological variables between the baseline measurements and data obtained during the test. Results were determined to be statistically significant if the p-value was less than 0.05.

*Worksheet*

The data included in this analysis indicates that participants who listened to rap music had similar scores on average compared to the participants that listened classical music (Table 1 & 2). The p-value obtained from comparing worksheet one scores between the two groups was deemed statistically insignificant ($p = 0.08$) (Figure 8). The average scores recorded from worksheet two for classical and rap music were 10.9 and 11.7, respectively (Table 1 & 2). Comparison of the results from worksheet two gathered did not illustrate any statistical significance ($p = 0.31$) (Table 4) (Figure 9). The average improvement scores from worksheet one to worksheet two calculated for classical and rap music were 3.27 and 2.94, respectively (Table 1 & 2). The change in score from worksheet one to two was slightly higher for classical music than for rap, but the t-test conducted provided insufficient evidence to reject the null hypothesis of a better retention for the classical group ($p = 0.28$) (Figure 10). Comparing worksheet one and two between the subjects, statistically significant results were found showing memory retention in each group. The p-value between the improvement scores for the classical group was 2.8E-06, while the p-value for the rap group was 2.4E-08 (Table 5). Due to

equipment errors, data from two classical subjects' respiration rate and two blood pressures of rap subjects were excluded.

*Heart Rate*

Figure 2 shows an example of the data collected. The average heart rate for the baseline and classical music group was 84.2 and 85.6 beats per minute (bpm), respectively (Table 1). The beats per minute were slightly higher when working on the worksheet, but with no calculated statistical significance ($p = 0.53$) (Table 3). Participants who listened to rap music while solving the problems on the worksheet had an average heart rate of 79.3 bpm, which was slightly lower than the baseline measurement of 80.4 bpm (Table 2). This result was statistically insignificant ($p = 0.60$). The average heart rate of participants of both the classical and rap music were compared (Figure 5). Even though the average heart rate for subjects were higher in the classical music group, the p-value indicated no statistical significance (Table 3).

*Respiration rate*

Figure 2 shows an example of the data collected. The average respiration rate found as the baseline for the classical group was 17.1 bpm. Participants in the classical music group had an average respiration rate of 17.6 bpm while completing the timed worksheet (Table 1). This measurement was slightly lower than the baseline measurement, but the results was statistically insignificant ($p = 0.59$) (Table 3). Subjects in the rap experimental group had an average respiration rate of 17.2 bpm. This value was lower than the baseline value of 18.7 bpm (Table 2). The p-value calculated after comparing the baseline and the rap group values showed no statistical significance ($p = 0.09$) (Table 3). The average respiration rate values for both music groups were compared (Figure 6). Despite the higher respiration rate for the classical group, the

p-value calculated the measurements were not statistically significant ($p = 0.75$) (Table 4). During data analysis for the worksheet, the following data was excluded due to equipment errors: the average respiration rate for two participants in the classical group, and one participant in the rap group.

*Blood Pressure*

The baseline measurement obtained of the average blood pressure (MAP) for the classical group was 84.1 mmHg. Participants in the classical musical group had an average blood pressure of 81.4 mmHg while solving the problems on the worksheet (Table 1). This value was lower than the baseline measurement for the average blood pressure, but the statistical test indicated that this difference was not significant ($p = 0.17$). The calculated average blood pressure for the subjects in the rap group while working on the worksheet was 83.7 mmHg. This value was also lower than baseline measurement of 85.6 mmHg (Table 2). After analysis, this difference was not statistically significant (Table 3). The subjects in the classical music group had lower average blood pressure compared to the rap musical group (Figure 7). The p-value obtained indicated no significance ($p = 0.25$). Average blood pressure was excluded from data analysis for one rap participant during the worksheet, due to equipment errors.

**Conclusion**

Our results concluded that there was insufficient evidence to demonstrate that neither rap nor classical music modified the level of stress in either of the subject pools. Therefore, our hypothesis that listening to classical music would lead to a decreased heart rate, respiration rate, and blood pressure, indicating a decreased physiological stress response, while in comparison

that rap music would increase these variables, was not supported by our study. There was no significant difference in the follow-up worksheet retention scores between the two groups. These findings did not align with a number of research studies that had been examined. For example, Bowman *et al.* had found classical music relaxed and reduced stress while Bernardi *et al.* had found that rap music generally increased blood pressure and heart rate, showing increased stress (2017, 2006). However, the study conducted by Bowman *et al.* was performed on kenneled dogs, and the study by Bernardi *et al.* had a small subject pool consisting of 24 individuals. These differing variables could account for differences in the stress responses seen in our subjects.

Calculations for the p-values between the rap and classical groups gave values of 0.24 for the heart rate, 0.75 for respiration rates, and 0.50 for mean arterial pressure. These values demonstrated that there was no statistical difference between any of the physiological measurements while completing the worksheet, so there is a lack of evidence to reject the null hypothesis. This exhibits that the two groups were at the same relative stress levels and worksheet scores did not display a significant effect resulting from stress.

The memory retention findings were significant for both groups, meaning that each group had a statistically significant improvement between scores from worksheet one to worksheet two. Worksheet two did not have any music playing, so it is interesting to note the difference in scores at this point. A study by Klatte *et al.* showed that no learning impairments occur with babble or continuous high or low frequency noise, as they are deemed as irrelevant sounds to the learner; so the subjects were able to ignore these sounds while completing the follow-up worksheet (2013). This could have made an effect in the improvement between worksheet one and two

scores as during the experiment. The music presented while completing worksheet one may have acted as a distraction to hinder scores; whereas the everyday noise that was present while completing worksheet two may not have affected the participants.

Some limitations of this project were the test subjects selected. Subjects were only allowed to participate if they were at least 18 years of age and were enrolled in Anatomy and Physiology 435. This specific and narrow test subject range could possibly skew results. Results could be influenced by these test subjects as from the fact that the students are well educated and could possibly do better on the worksheet tested than the general population. With a higher education, there could also be lower stress responses while taking a worksheet examination, due to the conditioning of often taking tests as a college student.

A confounding factor to this experiment may be the subject's preferential choice of music to listen and study to. Benefits of memory retention or increased scores can depend on the habits of the subject. Schellenberg *et al.* found that different types of music can improve performance on a range of cognitive tests. He states that the effects seen were brought about by changes in emotion; music puts one in a positive mood which influences performance to improve (2007). If one's mood is not positively changed, for instance if they do not normally listen or enjoy rap music, theses positive effects could be adverse. An added limitation of just having subjects be of a younger age range between the ages of 18-22 is that their top musical preference is hip-hop/rap. This differs greatly in older adults who prefer music from their young adult years and not what is popular now (Gibbons, 1977). This could positively influence the scores of the rap group subjects worksheet to be greater if they are accustomed listening to rap music while studying and experience an improved mood while listening.

A possible source of error was present while coordinating follow-up studies. If the subject was unable to perform the follow-up before or after lecture, we had to coordinate a time with them. This time was often during lab, a day before the follow-up would have been originally completed. A scarce amount of subjects were able to complete the worksheet within these two days and were contacted to meet at their earliest convenience; this longer wait of re-testing could have possibly decreased their retention scores slightly. Since this follow-up worksheet was identical to the first worksheet given during the experiment, it is possible that the subject had googled some of the trivia questions after the original experiment. This could lead to increased scores on the second worksheet given, but, nevertheless, would have had to involve memory retention during the two weeks between the worksheet examinations. Therefore, this should not have made a large impact in inaccurate scores. We made the assumption that the subjects followed the correct instructions while completing the follow-up worksheet. In addition, many did not complete the math problems or use the calculator because they didn't feel confident solving basic functions, so the test results varied from participant to participant. Consequently, scores may not accurately reflect the same type and number of questions answered if the harder problems were skipped over.

Future directions of this study could possibly measure different physiological measurements of stress while completing the same or similar worksheet examinations with mathematical, English, and trivia questions to see if other physiological responses may make a difference than the ones studied in this experiment. In addition, the experiment could use a wide range of participants, not necessarily only from Anatomy and Physiology 435, so to obtain results that will be applicable to the general population. This subject sample size was also

relatively small with 52 subjects tested total. Further experiments would want to include a larger sample size to ensure that the results are significant. Further experiments could additionally test with different music genre or song selections to observe if others make a significant effect over another.

It was important to take into account that people had performed better while completing worksheet two when there was no music playing, so it is possible that music in general was distracting. This might invoke the study to be taken in a completely different direction. We could experiment to determine if groups put under rap music or no music would perform better, so it would be appropriate if an additional control of a no-music group was added. It is possible that the worksheet did not induce a measurable stress response in either condition, so this no-music control would make clear if this was the case. If this was shown that the worksheet did not induce stress, additional elements could be added to create a more stressful environment and promote the appropriate physiological responses. This could possibly be done by having the subject able to see a timer of how much time they had left to complete as much of the worksheet as possible. Future researchers could also add an incentive of doing well on the worksheet, so there would be a consequence in performing well versus poorly or putting in little effort.

Overall, we could not conclude that classical or rap music demonstrated a significant difference in memory retention. The physiological measurements we tested did not show any significant differences between the test groups responses, so we cannot link these conditions to increased or decreased memory. From previous studies, it is debated that listening to classical music has more prominent benefits in learning and focusing than rap music, but we cannot conclude this with our study.

Many will find our research to be relevant because most people listen to music while studying, exercising, walking to and from work or class, or simply playing it in the background. This is particularly intriguing to college students because we see fellow peers studying while listening to music or some type of background noise. Our data illustrated that subjects who took our exam while listening to rap performed the same as those who listened to classical music. With this information, students in Anatomy and Physiology 435 may take it upon themselves to see if they can concentrate better while listening to rap or classical. Some may find one more distracting than the other which will be useful in advising other students what type of music might help them concentrate better in order to test well. Our study concluded that the type of music did not influence the physiological levels of heart rate, blood pressure and respiration rate between either type of music nor the first or second time taking the test. Memory retention was better the second time taking the test which may indicate that repetition of the same questions may help people recall more quickly so they can solve and answer more problems the second time around.

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**Tables**

| | Survey | n= | SD | Worksheet | n= | SD |
|---|---|---|---|---|---|---|
| Average Respiration Rate (Breaths per Minute) | 17.1 | 24 | 3.02 | 17.6 | 24 | 3.39 |
| Average Heart Rate (Beats per Minute) | 84.2 | 26 | 15.1 | 85.6 | 26 | 17.3 |
| Average Blood Pressure (MAP) | 84.1 | 26 | 11.2 | 81.4 | 26 | 13.7 |
| Average Worksheet 1 Score (out of 22) | | | | 7.67 | 26 | 2.38 |
| Average Worksheet 2 Score (out of 22) | | | | 10.9 | 26 | 3.23 |
| Average Worksheet Score Improvement | | | | 3.27 | 26 | 2.72 |

*Table 1:* Summary table of the averages for the Classical music group. Includes averages, number of participants used (n), and standard deviation (SD).

| | Survey | n= | SD | Worksheet | n= | SD |
|---|---|---|---|---|---|---|
| Average Respiration Rate (Breaths per Minute) | 18.7 | 26 | 6.01 | 17.2 | 25 | 4.24 |
| Average Heart Rate (Beats per Minute) | 79.3 | 26 | 14.4 | 80.4 | 26 | 13.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Average Blood Pressure (MAP) | 85.6 | 24 | 9.75 | 83.7 | 25 | 10.6 |
| Average Worksheet 1 Score (out of 22) | | | | 8.77 | 26 | 1.96 |
| Average Worksheet 2 Score (out of 22) | | | | 11.7 | 26 | 1.94 |
| Average Worksheet Score Improvement | | | | 2.94 | 26 | 1.84 |

*Table 2:* Summary table of the averages for the Rap music group. Includes averages, number of participants used (n), and standard deviation (SD).

| | n1 (Baseline) | 95% CI (Baseline) | n2 (Genre) | 95% CI (Genre) | p-value | Significant? |
|---|---|---|---|---|---|---|
| **Baseline vs. Classical HR** | 26 | 84.2 ± 5.80 | 26 | 85.6 ± 6.65 | 0.53 | N |
| **Baseline vs. Rap HR** | 26 | 79.3 ± 5.54 | 26 | 80.4 ± 5.11 | 0.60 | N |
| **Baseline vs. Classical RR** | 23 | 17.3 ± 1.16 | 23 | 17.8 ± 1.37 | 0.59 | N |
| **Baseline vs. Rap RR** | 25 | 18.7 ± 2.36 | 25 | 17.2 ± 1.66 | 0.09 | N |
| **Baseline vs. Classical MAP** | 26 | 84.1 ± 4.31 | 26 | 81.4 ± 5.27 | 0.17 | N |
| **Baseline vs. Rap MAP** | 23 | 85.8 ± 4.05 | 23 | 84.4 ± 4.33 | 0.22 | N |

*Table 3:* Summary table of the statistical results done for the baseline (survey) data compared with the stressed (exam) data. These were calculated using the paired, two-sided t-test. Some data was omitted from the calculations when there was a differing value of n so the sets could be compared. Includes number of participants used (n), 95% confidence interval (CI), and p-values.

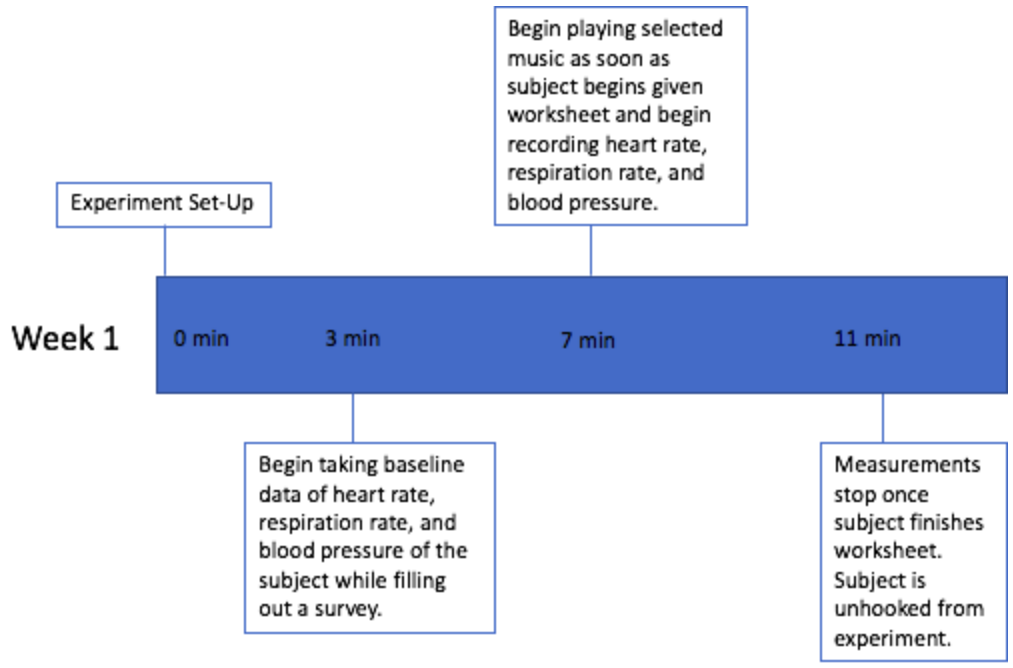
| | n1 (Rap) | 95% CI (Rap) | n2 (Classical) | 95% CI (Classical) | p-value | Significant? |
|---|---|---|---|---|---|---|
| **Rap vs. Classical HR** | 26 | 80.4 ± 5.11 | 26 | 85.6 ± 6.65 | 0.24 | N |
| **Rap vs. Classical RR** | 25 | 17.2 ± 1.66 | 24 | 17.6 ± 1.36 | 0.75 | N |
| **Rap vs. Classical MAP** | 25 | 83.7 ± 4.16 | 26 | 81.4 ± 5.27 | 0.50 | N |
| **Rap vs. Classical Wksht 1 Score** | 26 | 8.77 ± 0.753 | 26 | 7.67 ± 0.915 | 0.08 | N |
| **Rap vs. Classical Wksht 2 Score** | 26 | 11.7 ± 0.746 | 26 | 10.9 ± 1.24 | 0.31 | N |
| **Rap vs. Classical Wksht Improv. Score** | 26 | 2.94 ± 0.707 | 26 | 3.27 ± 1.05 | 0.62 | N |

*Table 4:* Summary table of the statistical results done to compare the Rap and Classical exam data. These were calculated using the unpaired, two-sided t-test. Includes number of participants used (n), 95% confidence interval (CI), and p-values.

| | n1 (wksht 1) | 95% CI (wksht 1) | n2 (wksht 2) | 95% CI (wksht 2) | p-value | Significant? |
|---|---|---|---|---|---|---|
| **Wksht 1 vs. Wksht 2 Score Rap** | 26 | 8.77 ± 0.753 | 26 | 11.7 ± 0.746 | 2.4E-08 | Y |
| **Wksht 1 vs. Wksht 2 Score Classical** | 26 | 7.67 ± 0.915 | 26 | 10.9 ± 1.24 | 2.8E-06 | Y |

*Table 5:* Summary table of the statistical results done to compare the exam 1 to the exam 2 scores. These were calculated using the paired, two-sided t-test. Includes number of participants used (n), 95% confidence interval (CI), and p-values.

**Figures and Legends**



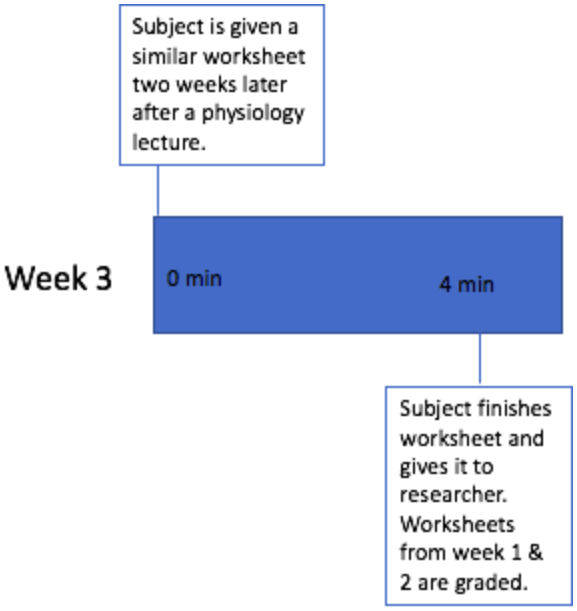



*Figure 1:* Experiment Timeline showing experiment progress in Week 1 and 3 respectively.

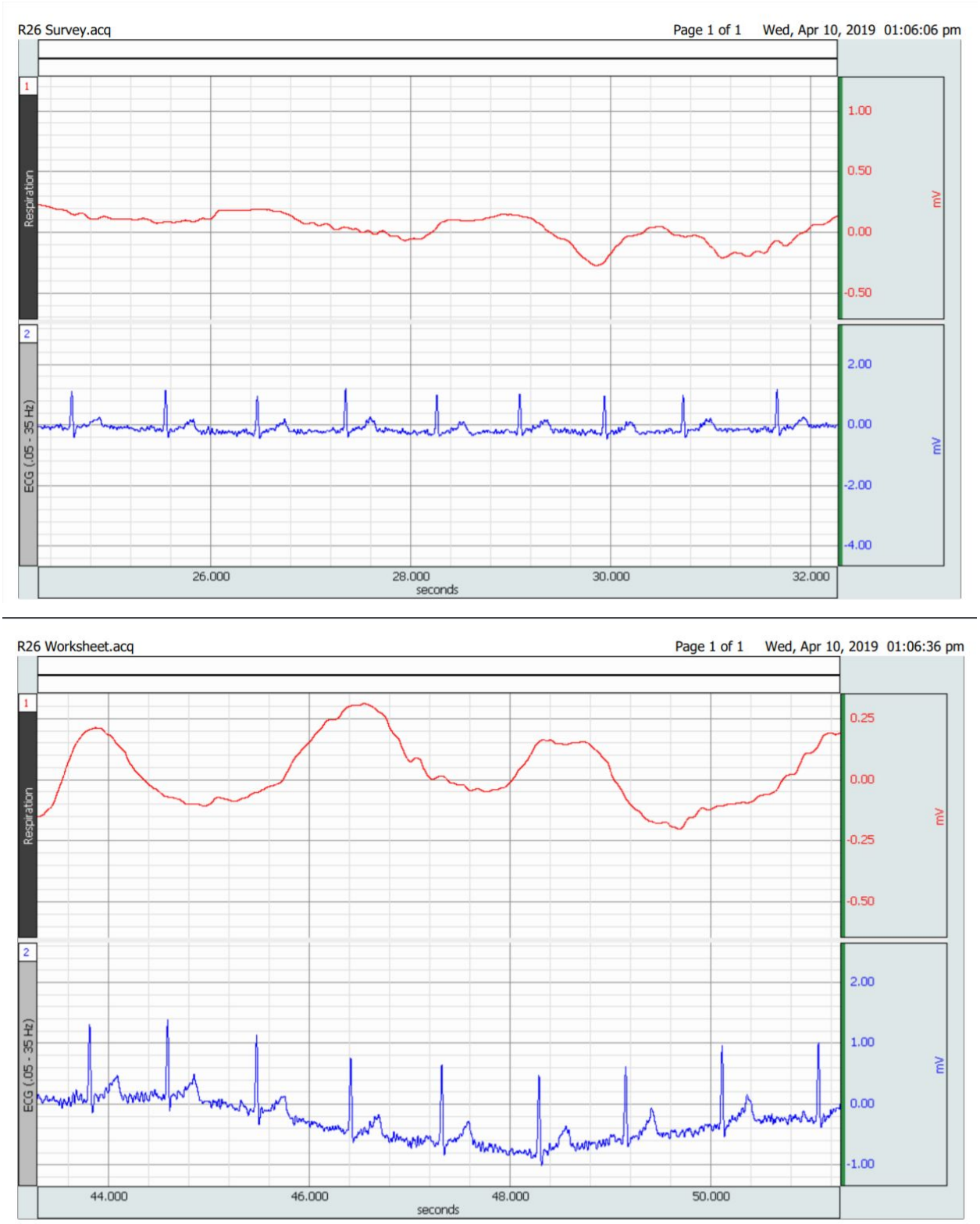



*Figure 2:* Snapshot of BioPac data recording software showing example measurements from one participant. Names have been removed to protect participant identity. The top picture shows respiration and heart rate associated with the Survey, and the bottom with the worksheet.

Respiration and heart rate was measured in millivolts on the y-axis and time in seconds on the x-axis. Each maxima of the respiration rate and heart rate was counted in order to analyze the data.

**Survey**

Name: _____

Email: _____

Can we contact you via email if needed: Yes No

Age: _____

Year in school: Sophomore Junior Senior Second-Year Senior Graduate
(circle one)

Major: _____

Amount of credits currently taking: _____

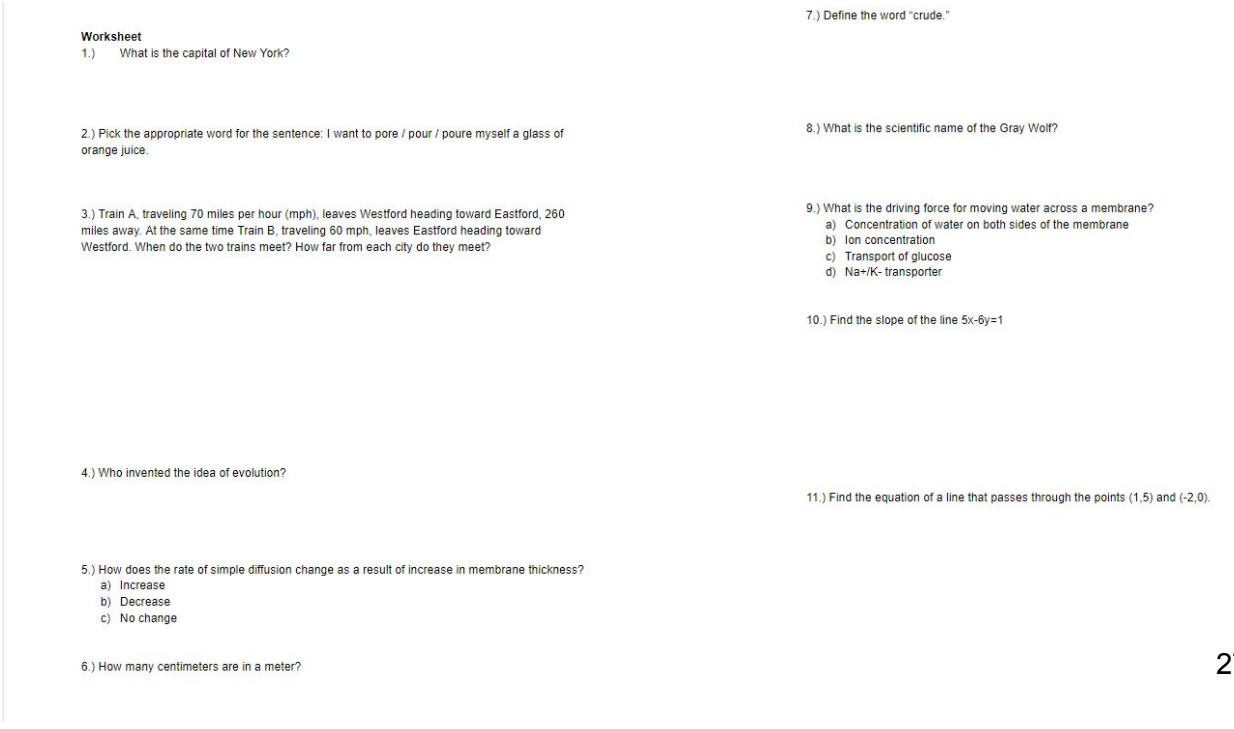
Favorite class this semester: _____

Do you regularly come to lecure: Yes Usually No

Are you willing to come to lecture on the Wednesday two weeks following this experiment:
Yes No

Which is your dominant writing hand? Right Left

*Figure 3:* A blank copy of the survey given to participants. Biological data recorded while participants filled out the survey was used to compare with the stressed (worksheet) conditions.



**Worksheet**

1.) What is the capital of New York?

2.) Pick the appropriate word for the sentence: I want to pore / pour / poure myself a glass of orange juice.

3.) Train A, traveling 70 miles per hour (mph), leaves Westford heading toward Eastford, 260 miles away. At the same time Train B, traveling 60 mph, leaves Eastford heading toward Westford. When do the two trains meet? How far from each city do they meet?

4.) Who invented the idea of evolution?

5.) How does the rate of simple diffusion change as a result of increase in membrane thickness?
a) Increase
b) Decrease
c) No change

6.) How many centimeters are in a meter?

7.) Define the word "crude."

8.) What is the scientific name of the Gray Wolf?

9.) What is the driving force for moving water across a membrane?
a) Concentration of water on both sides of the membrane
b) Ion concentration
c) Transport of glucose
d) Na+/K- transporter

10.) Find the slope of the line 5x-6y=1

11.) Find the equation of a line that passes through the points (1,5) and (-2,0).

12.) 7(x-4)+25x-(x+2)=-8x(45+12)-7 Solve for x.

13.) What is the oldest city in the United States?

14.) What is a suitable cotransporter (cation) with glucose?
a) K+
b) H+
c) Na+
d) Cl-

15.) Circle the errors in the following sentences:

a.) Its' raining cats and dogs!

b.) Their's always better food at the Jone's!

c.) The soldiers' are always practicing at all hours of the knight.

d.) An important part of my life have been the people who stood by me.

e.) In case you haven't noticed my real name doesn't appear in the article.

*Figure 4:* A blank copy of the worksheet exam given to participants, showing the variable questions from different disciplines used. The follow-up worksheet consisted of the exact same questions in the same order.

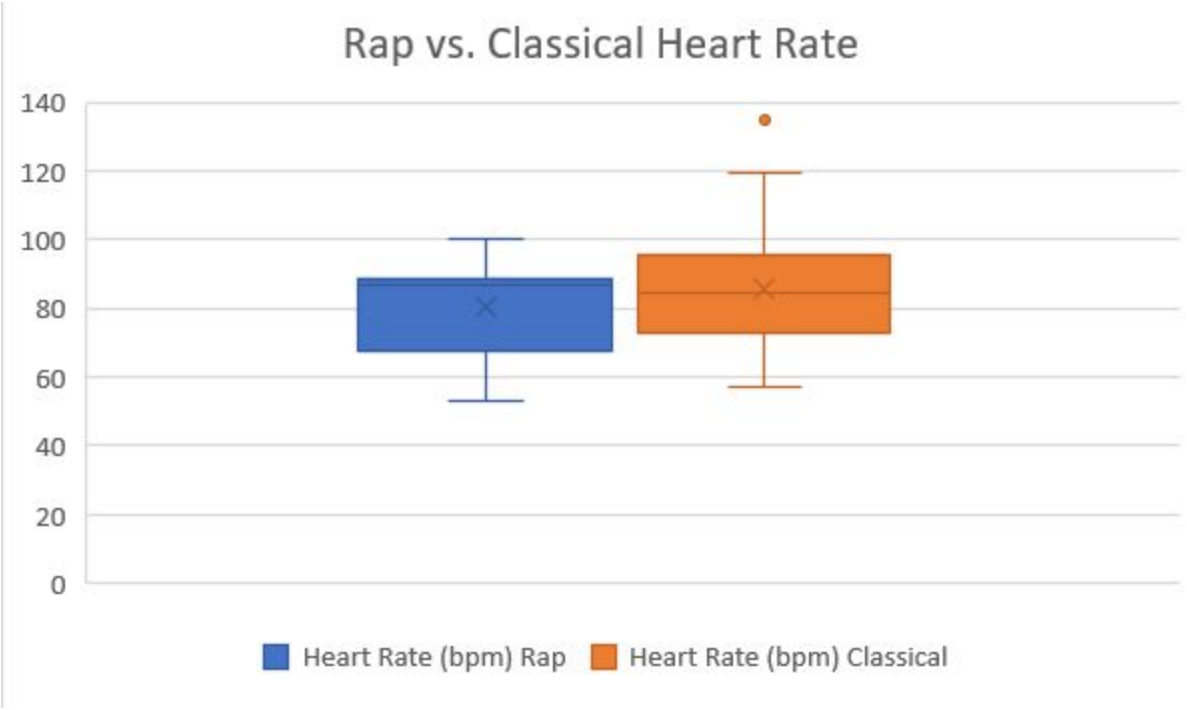



*Figure 5:* Graph comparing the heart rates of the Rap music group with those of the Classical group while taking the exam. Bpm stands for "beats per minute."

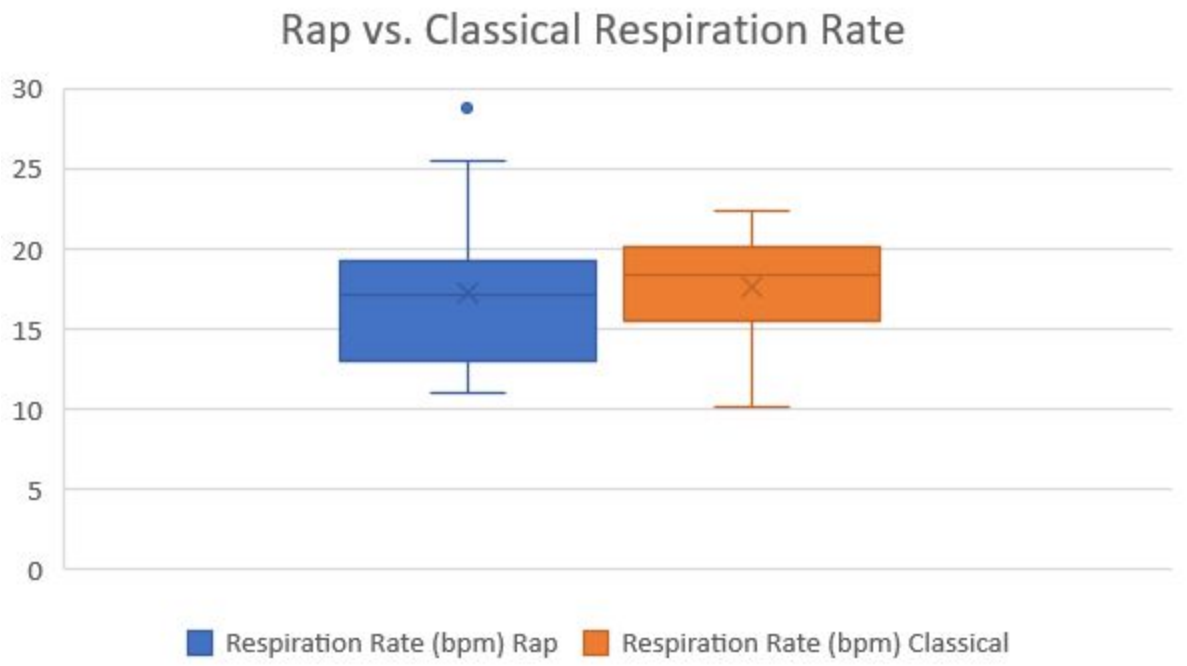



*Figure 6:* Graph comparing the respiration rates of the Rap music group with those of the Classical group while taking the exam. Bpm stands for "breaths per minute."

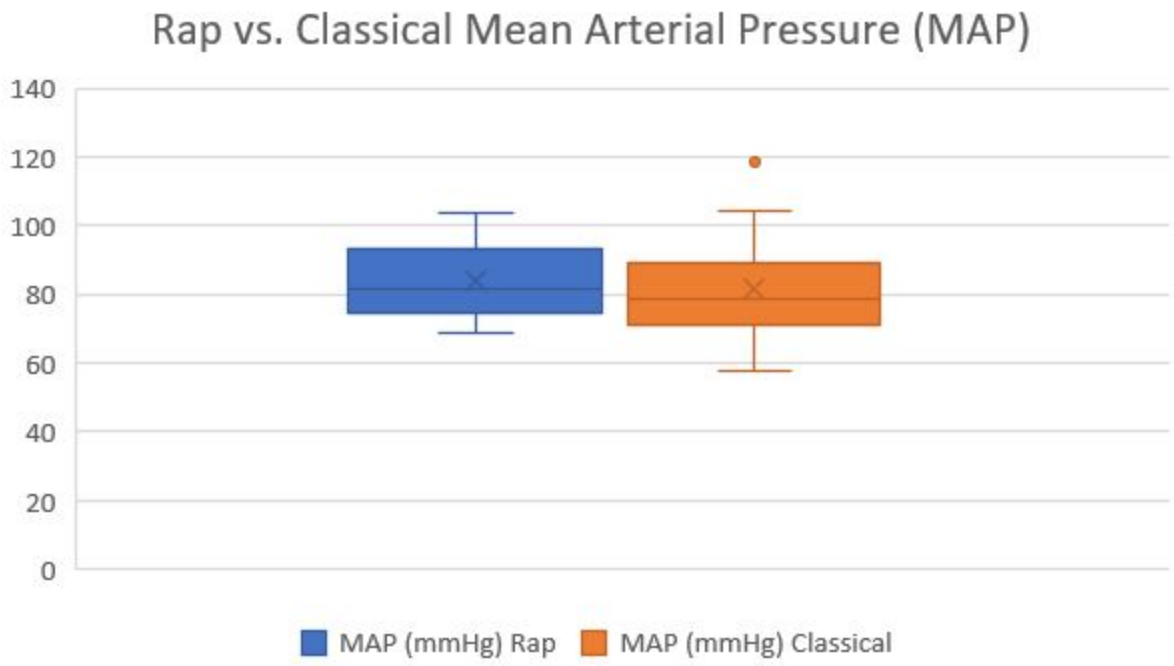



*Figure 7:* Graph comparing the Mean Arterial Blood Pressures (MAP) of the Rap music group with those of the Classical group while taking the exam.

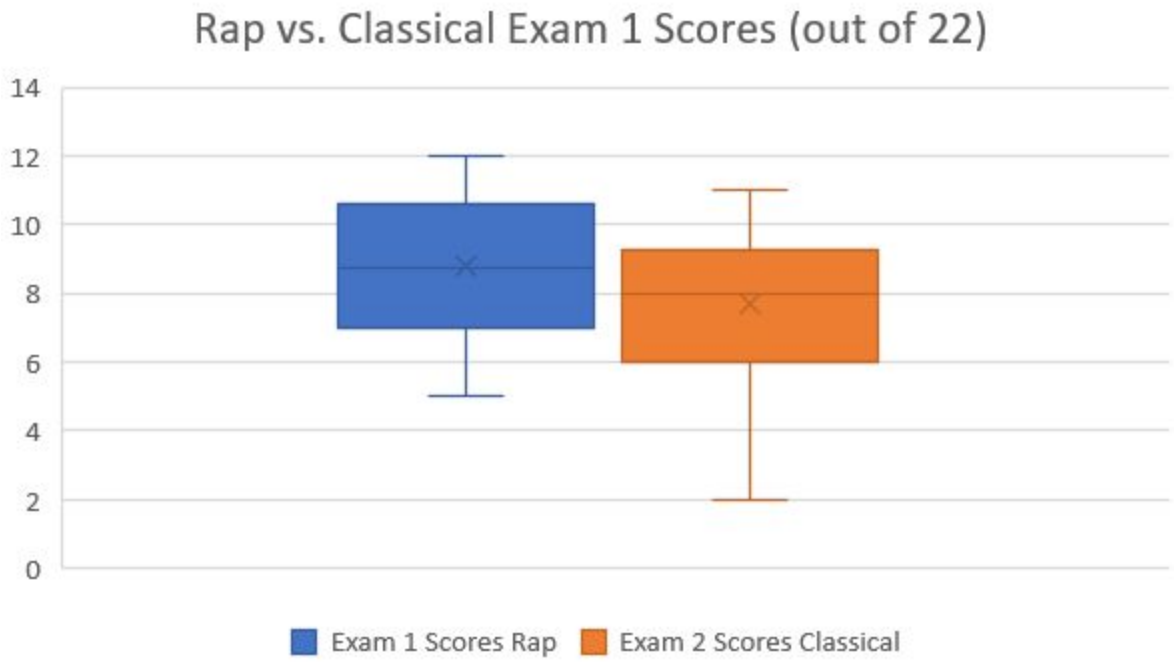



*Figure 8:* Graph comparing the exam 1 scores for the Rap music group with those of the Classical group.

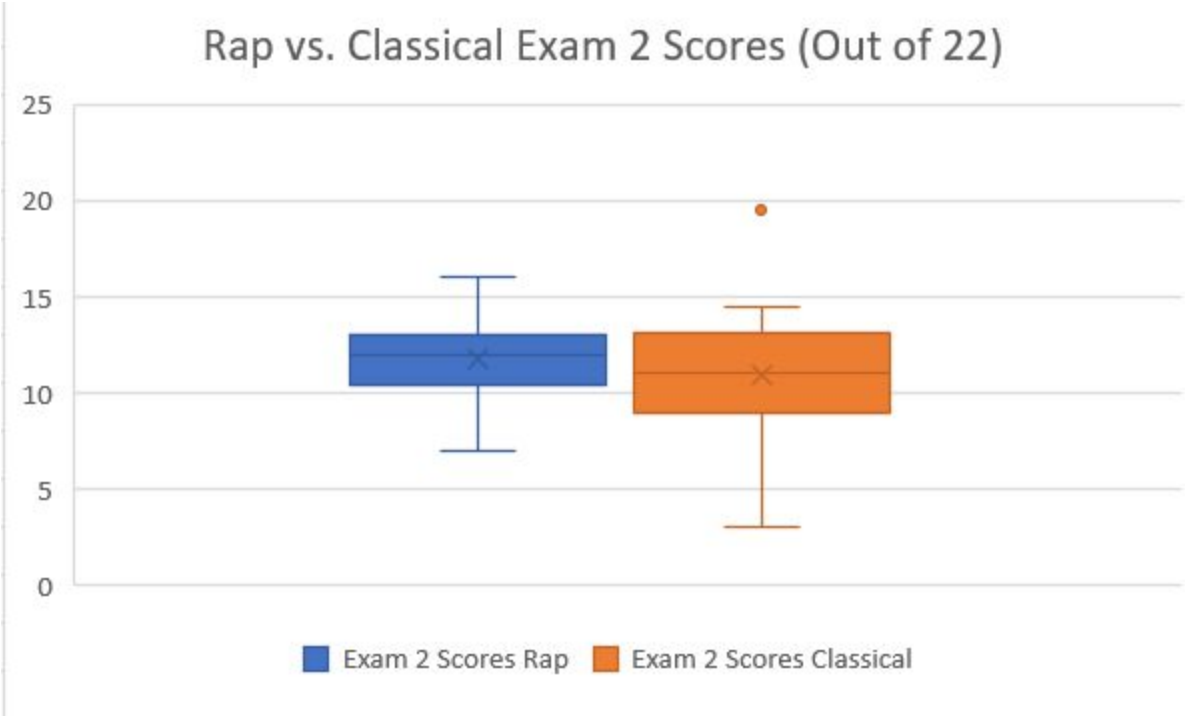



*Figure 9:* Graph comparing the exam 2 scores for the Rap music group with those of the Classical group.

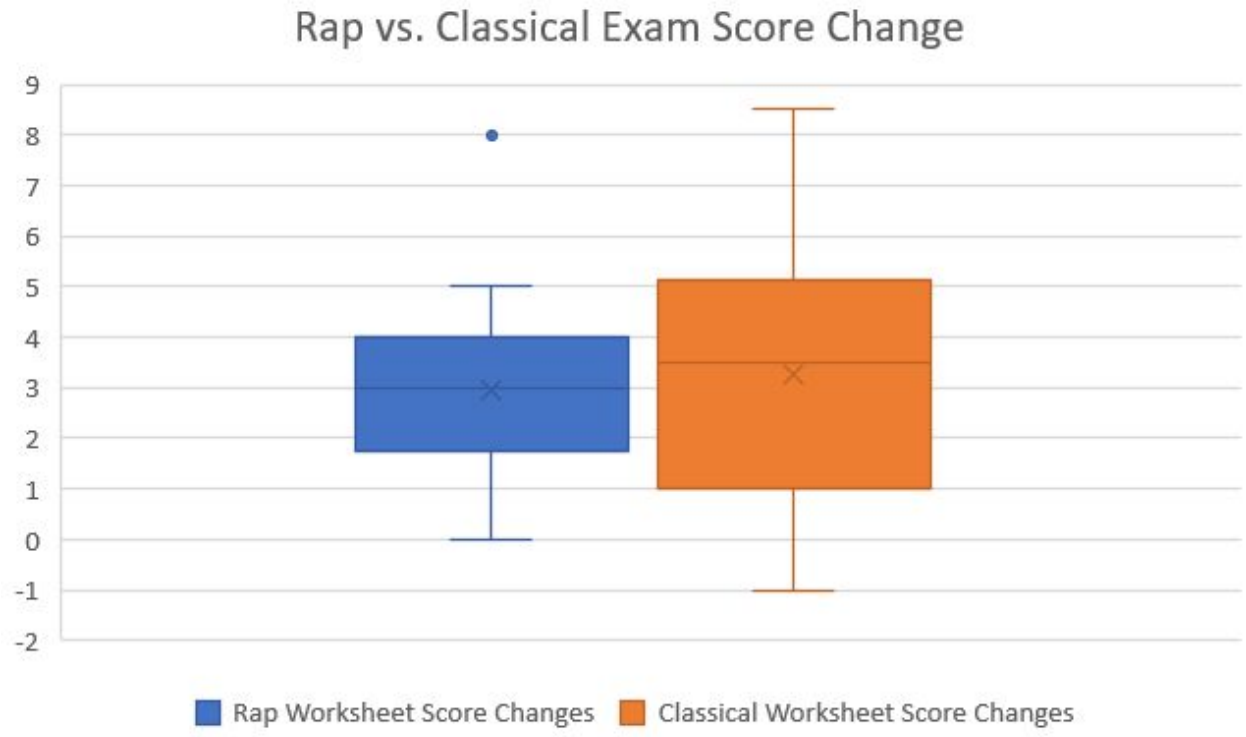


*Figure 10:* Graph comparing the change in exam one scores to exam two scores for the Rap music group with those of the Classical group. Calculated as exam two score minus exam one score.