Rock vs. Bach: Exploring the Impact of Different Music Types on Heart Rate

STATS 101B, Lecture 1

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Abstract

This article discusses the results of research conducted on the Island, a virtual civilization, regarding the effects of music type and listening duration on the change in heart rate (bpm). A two-factor blocked experiment was conducted, and 144 islanders from Bonne Santé were selected to participate. Equal numbers of male and female participants were sampled as research identifies the resting heart rate of males and females to differ, and we are not interested in studying this factor. The music types considered were classical and heavy metal which, based on literature, have opposing effects on heart rate, with heavy metal increasing heart rate and average and classical music generally decreasing heart rate. For the music type factor, a control level of no music was included to affirm any change in heart rate was a result of the imposed treatments rather than some other variable. A second factor, listening duration, was also considered and had two levels, 10 minutes and 20 minutes, with longer listening durations suspected to have an even greater effect on the change in heart rate. Islanders were randomly assigned to one of the six treatment groups, and heart rate was measured immediately before and after their assigned treatment was imposed. From this experiment, music type and listening duration were found to have a significant effect on the change in heart rate for the islanders of Bonne Santé.

Introduction

Research Questions

We tested two different research questions during our study. Firstly, we analyzed whether different types of music have an effect on an individual's heart rate. According to a 2014 study, music type has a significant impact on heart rate; classical music is linked to decreased heart rate and rock music is linked to increased heart rate (Sills 2015). Our study aimed to test whether this was true; as a result of the literature we read, we expected to see a negative correlation between classical music and heart rate, and a positive one between heavy metal and heart rate.

Secondly, we tested whether the amount of time an individual listens to a certain type of music has a significant impact on their heart rate. Various studies solidify the association between heavy metal music and increased heart rate as well as classical music and decreased heart rate by utilizing treatment groups and a control group (Roque et. al. 2013). Due to this literature and our intuition, we expected that a longer duration of listening to music would heighten its impact on heart rate (for example, we expected that 20 minutes of listening to classical music would decrease heart rate more than 10 minutes).

Variables of Interest

The variables that were of interest to our study were music type and listening duration. Our study aimed to test whether the type of music as well as how long it was listened to had a significant effect on an individual's heart rate.

Methods

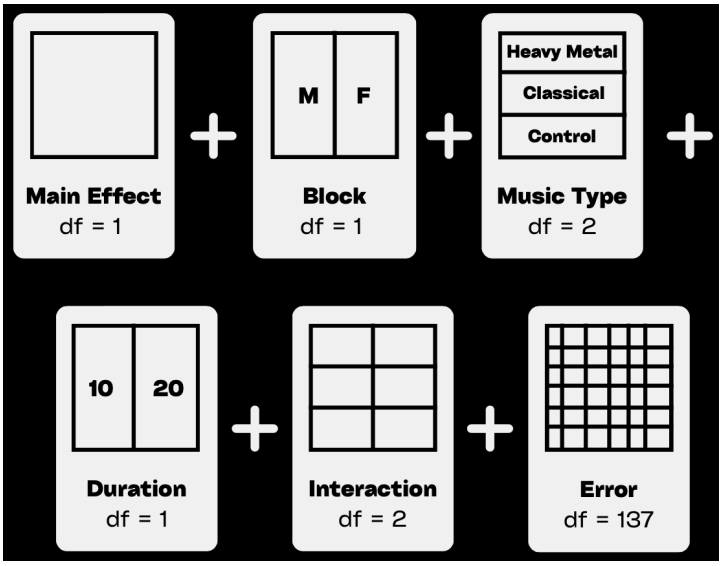
I. Participants

The participants of the study were 72 males and 72 females from the island of Bonne Sante. 16 islanders were selected from the total of 8 cities we sampled from (Pauma, Talu, Nidoma, Riroua, Gordes, Maeva, Colmar, Eden, Vaiku), and were then randomly assigned to different treatments after being blocked by gender.

II. Design

The design of our study was a randomized basic factorial with one block and two factors of interest. We blocked participants by gender to remove variability stemming from the innate differences in heart rate between the genders. The first factor was music type, which had three levels (classical, heavy metal, and control). The second factor was listening duration, which had two levels (10 minutes and 20 minutes). The response variable in the study was the difference in participants' heart rates in beats per minute (heart rate after treatment - heart rate before treatment). We also chose to study the interaction between the two factors to see if it had a significant impact on the response variable.

Factor Diagram



III. Mathematical Model and Hypotheses

$$y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \delta_k + \epsilon_{ijk}$$

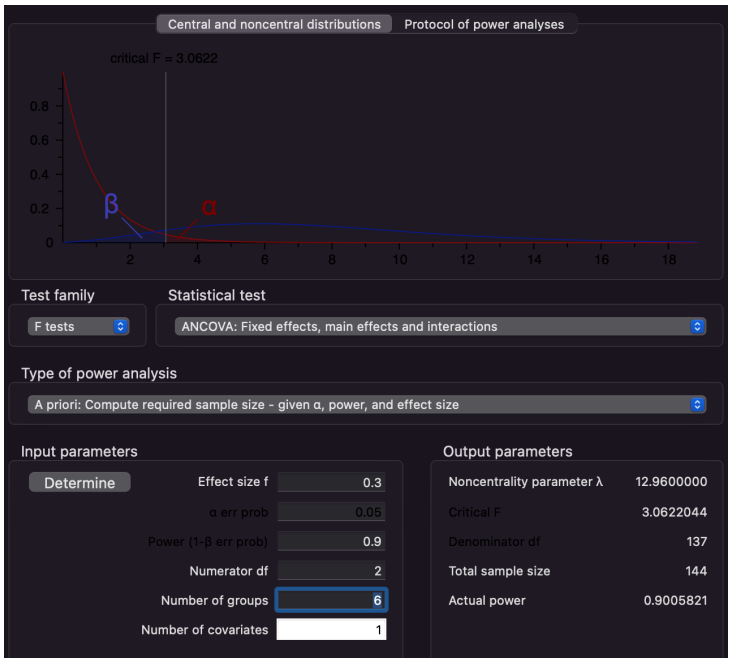
H_0: $\tau_1 = \tau_2 = \tau_3 = 0$ H_a: At least one τ_i does not equal 0.

H_0: $\beta_1 = \beta_2 = \beta_3 = 0$ H_a: At least one β_j does not equal 0.

H_0: $(\tau\beta)_{ij}$ equals 0 for every combination of i, j where i = 1, 2, 3 and j = 1, 2.

H_a: $(\tau\beta)_{ij}$ is not equal to 0 for at least one combination of i, j.

IV. Sample Size Determination



By utilizing G-Power with six total groups, effect size of 0.30, alpha level of 0.05, and power of 0.90, we determined that a sufficient sample size for this study would be 144 participants.

V. Instruments

In order to measure the heart rate of participants before and after their treatments, we used a pulse rate measure that reported their heart rates in beats per minute.

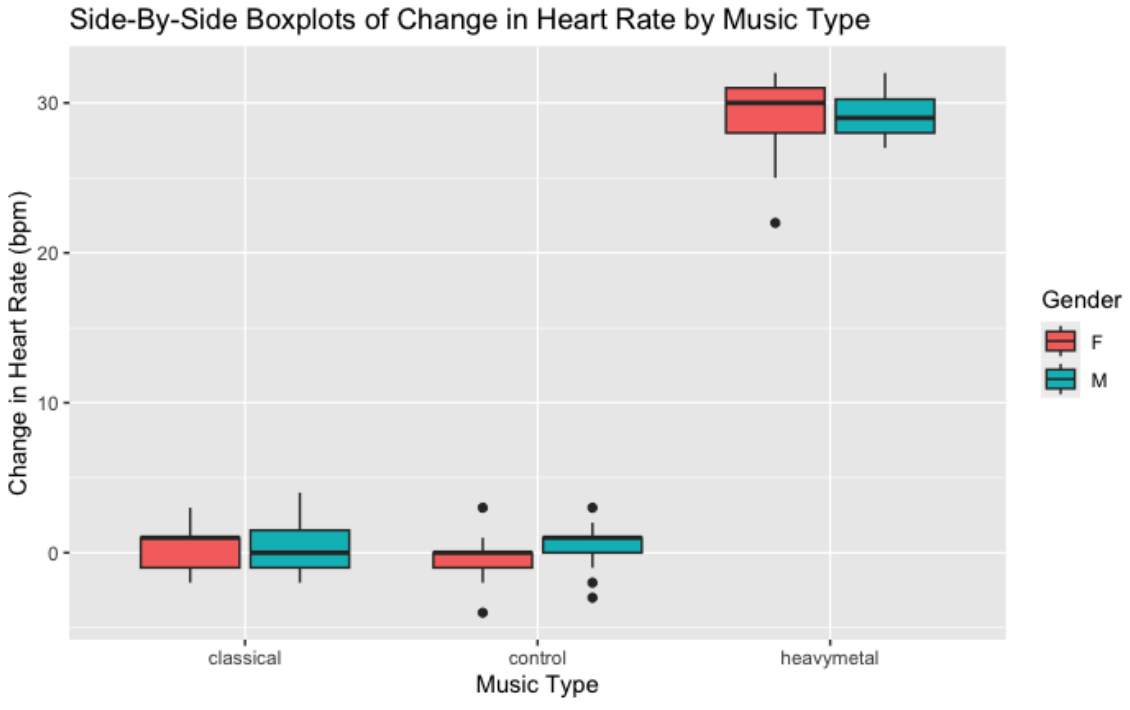
VI. Data Collection Procedure

All 144 islanders that we sampled were selected from the island of Bonne Sante in order to maintain constant characteristics between their environments. We sampled a total of 72 males and 72 females, selecting 16 each from the cities of Pauma, Talu, Nidoma, Riroua, Gordes, Maeva, Colmar, Eden, and Vaiku. Once we had our 16 islanders per city, we used random assignment to determine which treatments they would be assigned to. We wrote the islanders' names on slips of paper and put them into hats with the rest of the islanders from the same gender, then drew out islanders' names to assign them to a treatment (the six treatments were heavy metal, classical, and control for 10 minutes and 20 minutes each).

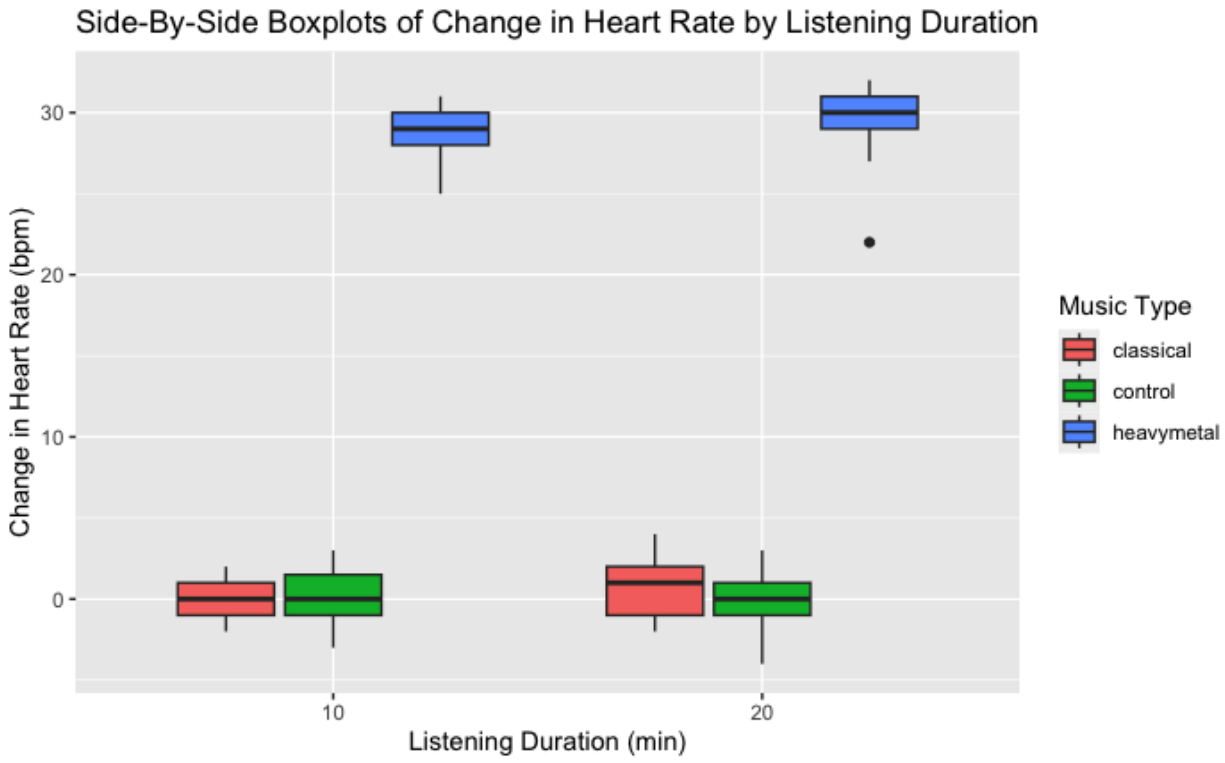
Exploratory Data Analysis

Box Plots

After collecting the data, we conducted initial exploratory data analysis to investigate which factors have the most significant effects on change in heart rate.

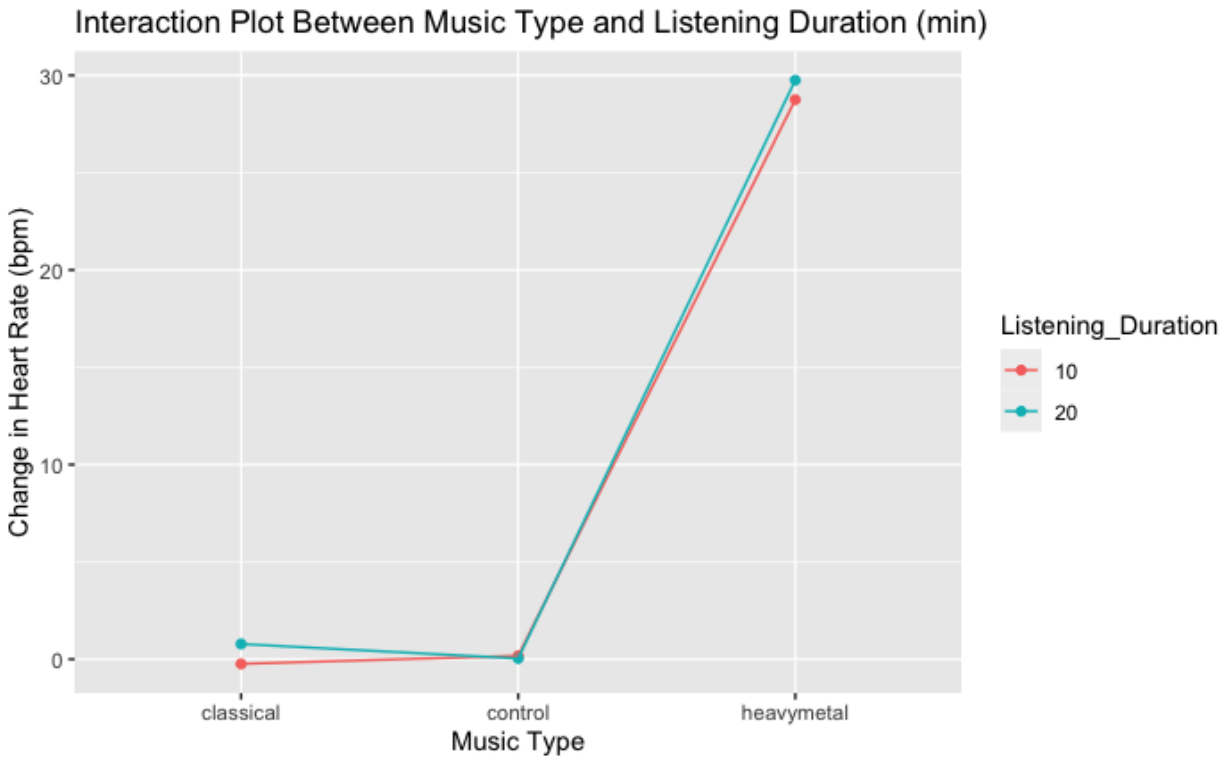


First, looking at the boxplots comparing the median change in heart rate by music type by gender, we can see that the centers of the distributions for males and females are slightly different, suggesting that the blocking factor may be a significant predictor in the model. Thus, this is a good indication that we were correct in blocking for gender since it does have an effect on the change in heart rate, but we are not interested in investigating this.



Now, looking at the boxplots comparing change in heart rate listening duration by music type, we can see that as expected, the average change in heart rate is much higher for those that listened to heavy metal music, with the middle of the 20 minute duration being slightly greater than that of the 10 minute listening duration. However, for both listening durations, the averages for change in heart rate for classical music and our control group are nearly equal, which was not expected to happen based on literature stating that classical music tends to decrease heart rate.

Interaction Plot



The interaction plot shows no dramatic changes in the rates between the lines connecting the marginal averages, thus we do not suspect an interaction between the factors listening duration and music type.

Results

ANOVA Model Summary and Analysis

	DF	Sum Sq	Mean Sq	F-Value	P-Value
Music Type	2	27048	13524	5201.698	<2e-16 ***
Time Duration	1	14	14	5.486	0.0206 *
Gender	1	9	9	3.451	0.0654 .
Music Type : Time Duration	2	9	5	1.742	0.1791
Residuals	137	356	3		

From the output of the full model, we can see that music type has a highly significant effect on change in heart rate, and time duration is also significant at the α = 0.05 level. However, as visually expected, the interaction term between music type and time duration does not have a significant effect on our response variable. Thus, we will attempt to remove it.

Reduced Model Summary

	DF	Sum Sq	Mean Sq	F-Value	P-Value
Music Type	2	27048	13524	5146.766	<2e-16 ***
Time Duration	1	14	14	5.428	0.0213 *
Gender	1	9	9	3.414	0.0668 .
Residuals	139	365	3		

By removing the insignificant interaction term, we can now see that all of the predictors in the model are statistically significant. However, we note that for the full model, R_{full}^2= 0.9870177, while for the reduced model, $R_{reduced}^2$= 0.9866876 (decreased by 0.0003301). So, we will conduct a partial F-test to confirm that there was not a significant loss in information about the variation of change in heart rate, and we should remove the insignificant predictor.

Partial F-test Summary

	Res.DF	RSS	DF	Sum of Sq	F-Value	P-Value
1	139	365.25				
2	139	356.19	2	9.057	1.7418	0.1791

Since the p-value of the partial F-test is insignificant at the Ɑ = 0.05 significance level, we conclude that we do not need to consider the full model, and we can use the simpler, reduced model without the interaction effect.

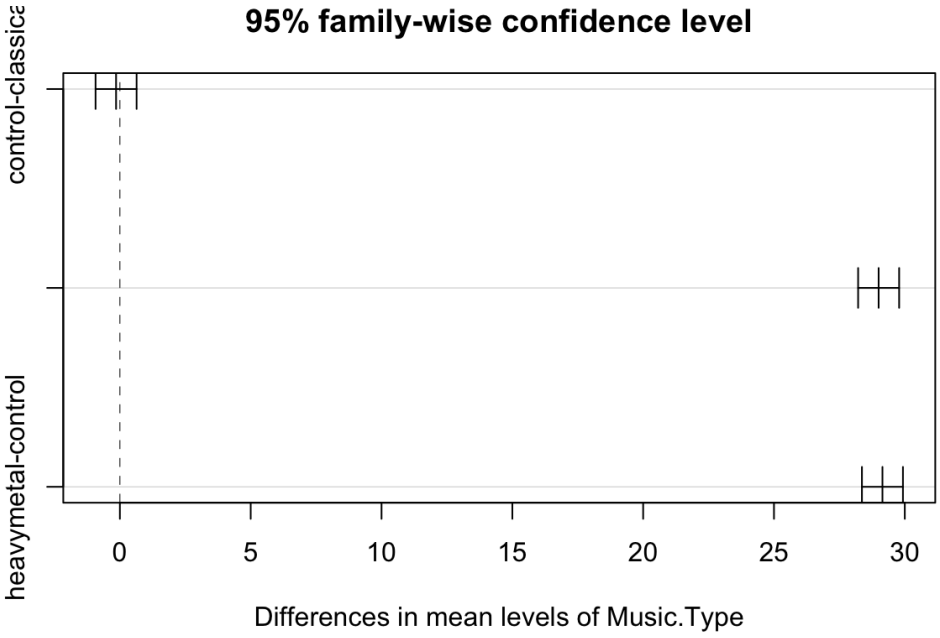
Post-Hoc Analysis

Numerical Results of Tukey HSD Test

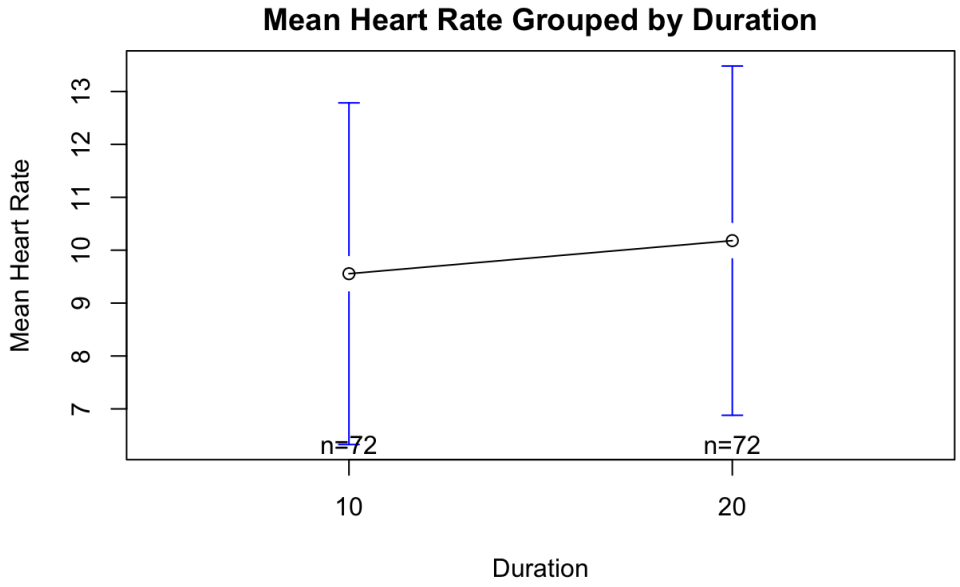
Variable	p-value adjusted
control-classical	0.8980247
heavymetal-classical	0.0000000 ***
heavymetal-control	0.0000000 ***
20min-10min	0.0204021 *

This test indicates that the most significant difference in mean heart rate occurs between heavy metal and classical, and heavy metal and control. The difference in mean heart rate between the 20 and 10 minute durations is also slightly significant, whereas the difference for control and classical is not significant, with a p-value above 0.05.

Plot of Tukey HSD



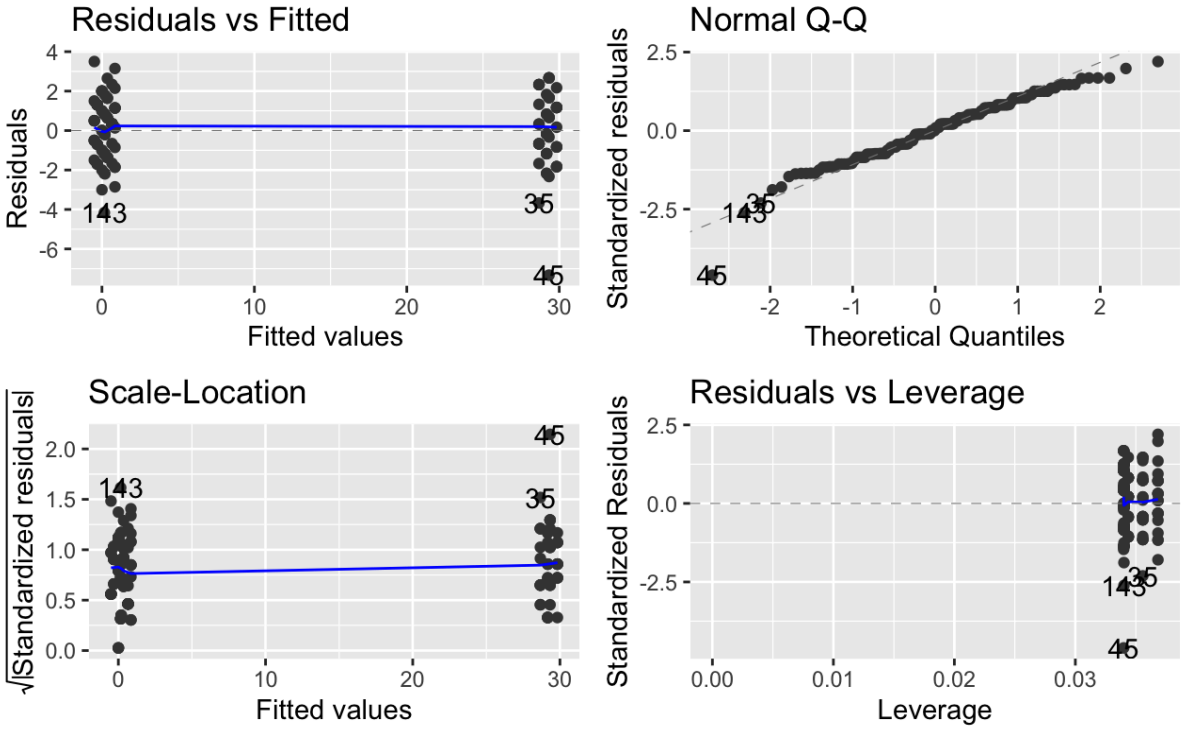
Plot of Mean Heart Rate by Duration



This plot indicates that the mean heart rate is slightly different for the two durations, and is higher for a duration of 20 minutes rather than a duration of 10 minutes.

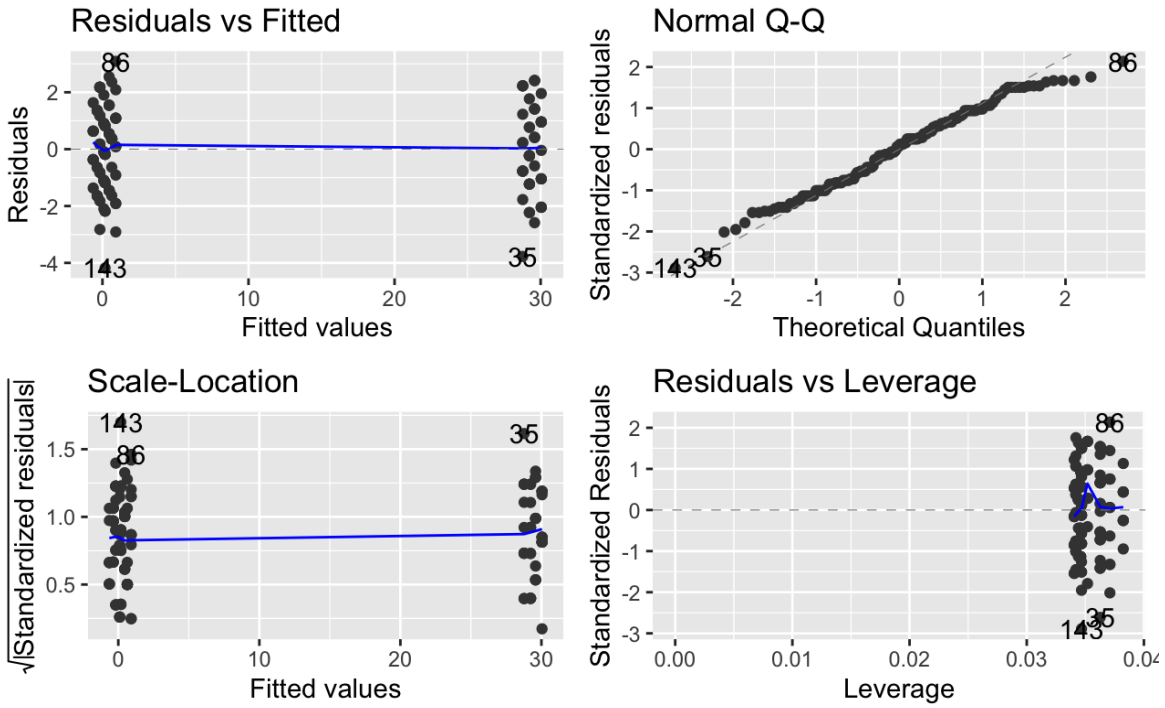
Model Diagnostics

Plots to Evaluate Validity of Model



Looking at these plots, it is clear that there are several outliers. Upon further analysis, points 46 and 140 are two main outliers, which we will remove to better satisfy the model assumptions.

Diagnostic Plots for New Model



With the outliers removed, the model much better meets the assumptions of constant variance and normality of the error terms, with most of the points on the Normal-QQ plot falling on the line, and both the residuals vs. fitted and scale-location showing random scatter.

Discussion

Analysis and Conclusions

We first loaded all data collected from the islanders into R, and created a linear model for the data, with the response being heart rate, the two factors being duration and music type, and

the blocking factor being gender. The interaction between duration and heart rate is also considered in the original model. The ANOVA tables shown above suggest that while both duration and music genre are significant factors (both p-values are less than 0.05), their interaction is not significant in predicting mean heart rate (its p-value, 0.1791, is greater than 0.05). The blocking factor, gender, has a p-value of 0.0654, proving it is a significant source of variation. Thus, blocking by gender was a good way to eliminate a nuisance factor in the model. After creating a new model without the interaction term and running a partial F-test with the full and reduced model, it is evident that the reduced model is a better fit for the data (the p-value of the test. 0.1791, is greater than 0.05). From the ANOVA results, it is clear that there is an association between music type heart rate, as well as music genre and heart rate (the association between heart rate and music type is much stronger, as the p-value is much closer to 0).

After running the post-hoc Tukey HSD tests, we can conclude that the difference in mean heart rate between heavy metal and classical, as well as heavy metal and control, are very significant, while the difference in mean heart rate between control and classical is not. This indicates that heavy metal is the only music genre that produced significant change in the mean heart rate of the islanders. Looking at the plot of mean heart rates between the 10 vs. 20-minute durations, it is clear that the 20-minute duration produced a significantly higher mean heart rate than the 10-minute duration.

Heart rate can be influenced by a myriad of factors–music being one of them. Our results, for the most part, do align with the literature. It is clear that listening to heavy metal significantly increased islanders' heart rates, as predicted by several studies we examined. However, the mean heart rate for classical music did not differ from the mean heart rate for the control group, which contradicted the results from the literature, which suggested that classical music would

significantly decrease mean heart rate. Also, the literature suggested that duration would significantly impact one's heart rate–that listening to music for longer would increase the impact a given music genre may have on one's heart rate. Our results did align with these findings, as the duration variable was found to be significant in the ANOVA results. Finally, several studies have shown what a large impact gender has on one's heart rate. This was confirmed by our study, as we found gender to be a significant blocking factor that positively reduced variation in our model.

Limitations to Design

One potential limitation to our design is the fact that we cannot randomly select islanders. The ability to do this (on top of randomly assigning them treatments) would increase the potential for randomization and reduce variation/bias in the model. Also, to improve our design in the future, we could obtain a larger sample size (including sampling islanders from the other two islands), which would result in an even higher power (increasing the validity of our study). We could also include more levels of our factors, for example, study more music genres (country, dance, EDM, rap, etc.), and longer durations (30 minutes, an hour, etc.), to broaden our range and obtain more information. Finally, we could further reduce variation in the model by examining other potential nuisance factors–such as age, activity level, and smoking status–that may have effects on heart rate.

Future Research Questions

(1) How does listening to different music genres affect other factors in humans, such as blood pressure and mood?

- According to a 2022 study by the NIH Center for Biotechnology Information: Listening to fast music increases systolic and diastolic blood pressure, and listening to slow music

had the opposite effect. While slow music was found to be calming and fast music uplifting, both improved mood levels (Darki et. al. 2022). This study could be expanded to different genres of music (rather than just slow and fast).

(2) How do heavy metal and classical compare with other genres of music such as country, pop, EDM, rap, etc. in terms of producing changes in heart rate (and other factors such as blood pressure and mood)?

(3) How does listening to different genres of music while studying affect concentration, comprehension, retention, and performance in academic settings?

- According to a 2016 study, experimental data revealed higher percentages of correct answers from students who listened to soft music rather than other fast track or instrumental music while studying (Kumar et. al. 2016). However, more data is required to analyze comprehension and retention across a wide variety of music genres.

(4) Is there a connection between the genre of music one frequently listens to and one's mental health? What is this connection?

- A 2008 study found that relationship between various genres of music and antisocial behaviours, vulnerability to suicide, and drug use. However, the study states that more research is needed to determine whether music choices of those with diagnosed mental health issues differ significantly from the general adolescent population, which may make for an interesting study in the future (Baker et. al. 2008).

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