Examining the Relationships Between Music Treatment, Gender, and Pain Threshold of Islanders

Aurora Belen Ignacio, Avery Robinson, Mabel Sekarputri, Brandon Wang, and Zoe Wang

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Abstract

Millions of Americans suffer from chronic pain. This condition has far-reaching societal consequences, extending from limitations in quotidian domains to the opioid epidemic. Due to the multitude of issues chronic pain invokes, it follows that further study is needed to find safe and effective treatments for this condition. A growing body of literature suggests that music decreases the perception of pain. Additionally, several of these studies attribute differences in effectiveness of music treatment on pain to gender. We set out to test these claims on islanders using a two-way randomized block design. We sampled 162 participants, blocking according to age group, with an equal number of females and males. Treatments were randomly assigned to islanders, with one third not listening to music, one third spending 10 minutes listening to classical music, and one third spending 10 minutes listening to heavy metal music. Pain threshold was measured immediately afterward. After conducting a two-way ANOVA analysis of our results, we found that age is the only significant factor in determining pain threshold among the islanders. Seniors had significantly higher pain thresholds than the two younger age groups. Gender, music, and their interaction effect were found to be not significant.

Introduction

Chronic pain affects an estimated 20.4% (50 million) of adults in the U.S. today. This condition has been linked to restrictions in daily activities, anxiety and depression, opioid dependence, and a generally poorer quality of life (CDC). The global chronic pain treatment market was valued at $77.8 billion in 2019 and is expected to grow further in the coming decade (P&S Market Research). Although we do not expect music to be a cure-all treatment for chronic pain, existing literature has led us to believe that it is worth exploring as a treatment option due

to its low-cost, low-risk, and accessible properties. Applications would not be limited to chronic pain—if music decreases perceived discomfort, the use cases could logically be extended to other pain situations, such as acute injuries.

Additionally, we want to investigate the relationship between gender and pain threshold, as well as gender's interaction effect with music. One study found that men's pain thresholds were significantly higher than women's with or without music (Furuta et al.), whereas another found a significant interaction between gender and pain threshold, hypothesizing that "music can affect women more easily than men." (Ghaffaripour et al.) We find these claims important to investigate given that the results could have far-reaching applications.

Methods

Participants

Our participants are virtual humans - residents of the *Island*. Based on evidence for pain threshold changing with age (El Tumi et al.), we decided to block our participants by age group: Youth (15-24), Adults (25-64), and Seniors (65+). We chose to not make age a design factor as we wanted to focus our attention on gender and music genre, yet since it might affect results we are hoping that using it as a block will increase our ability to detect a true difference in pain threshold. Given our single block and two design factors, we chose to do a two-way randomized block design with ANOVA analysis. Our desired power level for our study was 0.80, and after sample size calculations, we concluded to have a sample size of 162. We sampled systematically by randomly choosing initial starting locations and then asking every eligible islander (15 years and older) in those locations to participate in our study until we had 27 females and 27 males in each age group.

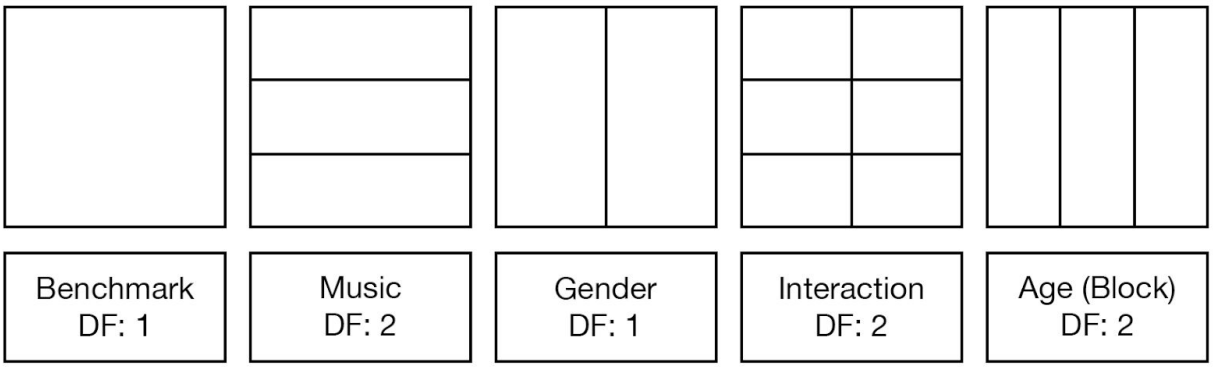
Design

Our study is constructed as a two-way randomized block design which can be visualized through the following table:

Response Variable	Pain Threshold		
Blocking Factor (Age Group)	Youth	Adult	Senior
Design Factor (Gender)	Male		
	Female		
Treatment (Music)	Control (No Music)	Classical	Heavy Metal

A two-way randomized block design is useful when we want to study the effects of more than one treatment, while also observing how a nuisance factor behaves as a source of variation. By blocking by age group, we sought to minimize any variation caused by age in our study on the significance of music's effects on pain threshold.

We used the following factor diagram:



Materials and Procedure

To collect our data, we started by assigning the locations on the Island to numbers ranging from 1 to 35. Using a random number generator in R, we selected our initial starting points based on the output. Next, we invited each islander above the age of 15 years to participate in our study until we had accumulated 27 females and 27 males in each age group. To assign a treatment to each individual, we again utilized a random number generator to assign a treatment to individuals in each corresponding age group and gender, with 1 corresponding to our control group (no music), 2 to classical music, and 3 to heavy metal music. This process continued until each treatment group was filled and we were left with nine individuals per treatment in each of the corresponding age and gender divisions.

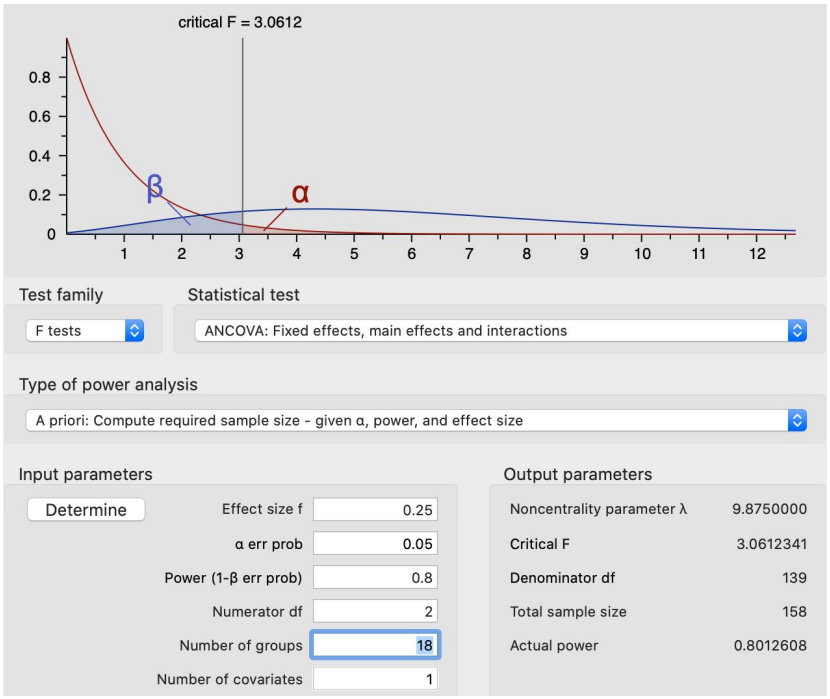
We chose classical and heavy metal music because we hypothesized that they could affect and possibly increase pain threshold in different ways: classical music could calm the islanders, whereas heavy metal could give them more energy and willpower. Using the virtual tasks on the Island, we instructed the classical and heavy metal groups to listen to their respective music genre for 10 minutes. Immediately afterwards, a "Pressure Pain Threshold Biceps" test was administered on all participants, including the control group. This test measures pain threshold by using an algometer to apply increasing levels of pressure on the bicep until the patient indicates that they have reached a degree of unpleasant pain (Walton et al.). After the test was complete, we recorded the pain threshold of each participant, which corresponds to the "unpleasant" pressure level, measured in kPa.

Data Analysis

To analyze our data, we loaded the observations into R and created a model using the aov() function. Then, using the plot() function on our model, we checked for the regression assumptions of normality and constant variance. We used ANOVA and the accompanying F-tests to see if any of the factors in our experiment had a significant effect on pain threshold. The control group of no music was used as a point of comparison for the treatments of classical and heavy metal music.

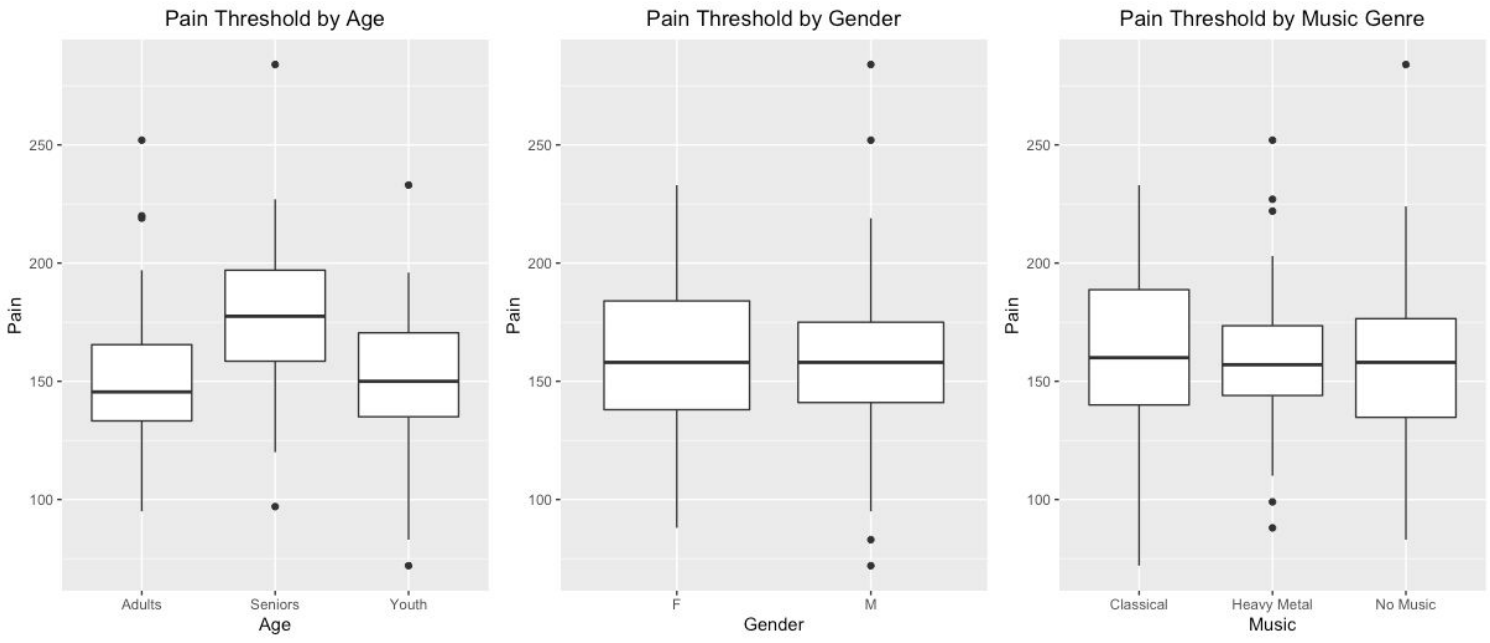
Sample Size Determination

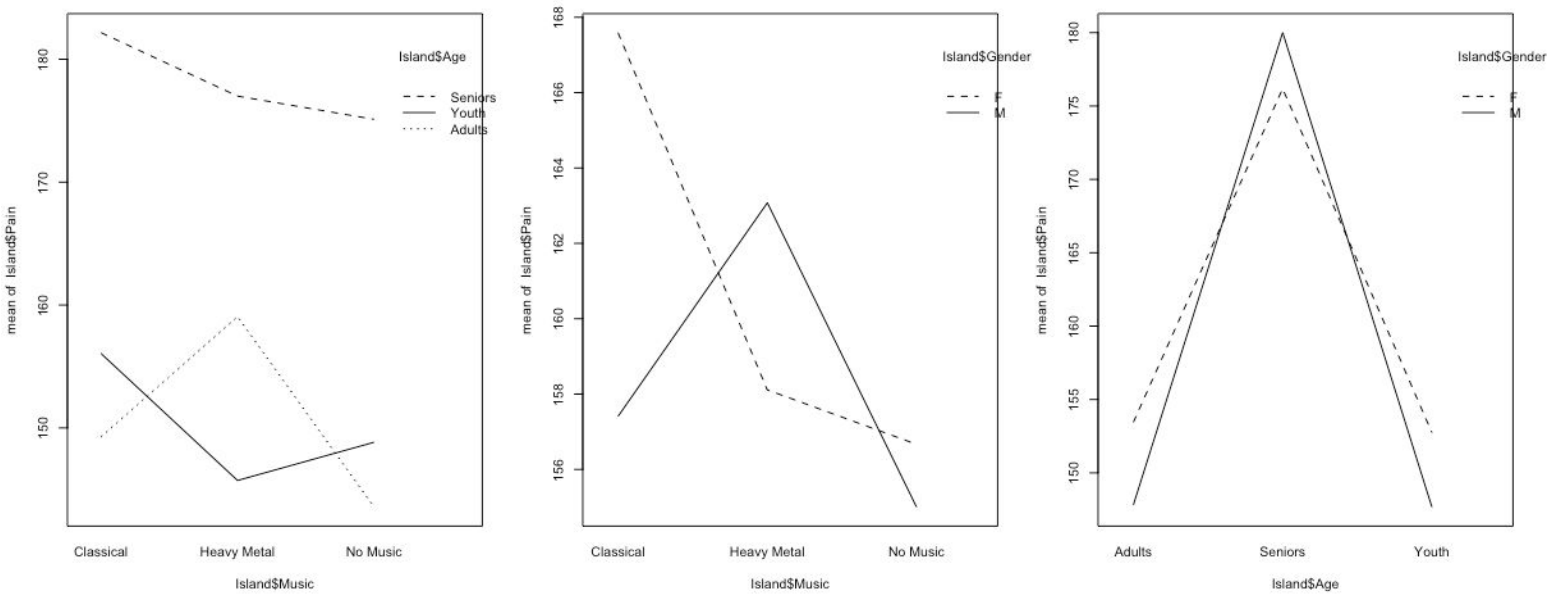
Our desired power level was 0.8, which signifies the probability that our experiment will reject the null hypothesis that gender and listening to music have no effect on pain threshold, given that the null hypothesis is indeed wrong. Additionally, we chose an alpha level of 0.05, which corresponds to the probability of incorrectly rejecting the null when it is in fact true. Our effect size of choice is 0.25, which represents the difference between our groups, and our largest possible degrees of freedom is 2. Using the factor with the largest degrees of freedom is a safer choice in determining sample size. By plugging these into the GPower software, we found that the minimum sample size to achieve our desired power level is 158 islanders. However, in order to achieve a balanced experimental design, we chose to sample 162 islanders instead (3 age groups, 27 males and 27 females per age group, 9 of each gender group assigned to the 3 music treatments).



Results

Exploratory Analysis:



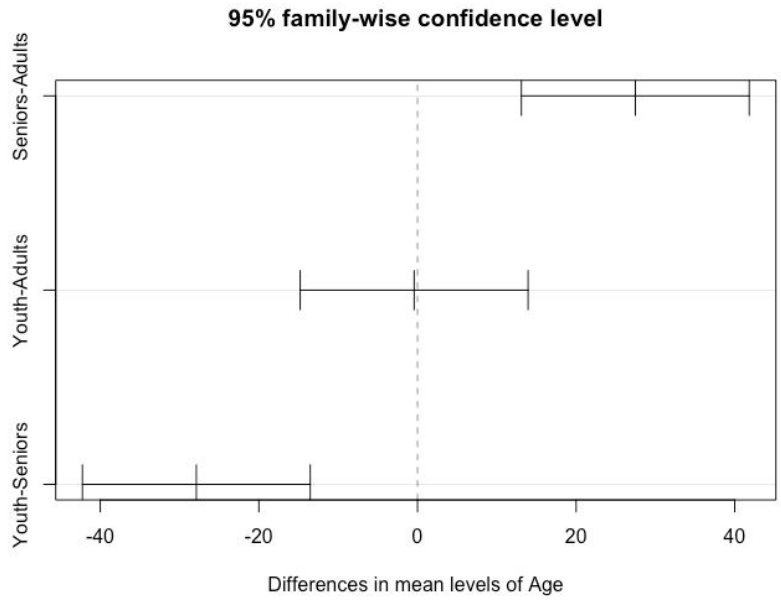


ANOVA Analysis:

	DF	Sum Sq	Mean Sq	F Value	Pr(>F)
Gender	1	214	214	0.216	0.643
Music	2	1273	637	0.645	0.526
Age	2	27579	13790	13.967	2.66e-06
Gender:Music	2	1557	778	0.788	0.456
Residuals	154	152040	987		

Post Hoc Analysis via TukeyHSD on the Age factor:

	Difference	Lower	Upper	P adjusted
Seniors - Adults	27.4629630	13.15227	41.77366	3.322353e-05
Youth - Adults	-0.4259259	-14.73662	13.88477	9.972685e-01
Youth - Seniors	-27.8888889	-42.19958	-13.57819	2.473207e-05



Checking Model Adequacy:

$y_{ijkl} = \mu + \alpha_i + \gamma_j + \beta_k + (\alpha\gamma)_{ij} + \epsilon_{ijkl}$

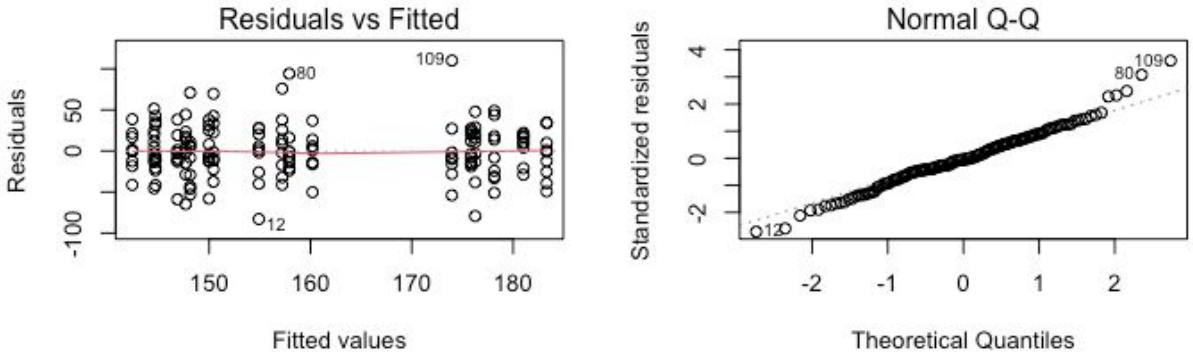
effect of gender: α_i for i = 1, 2

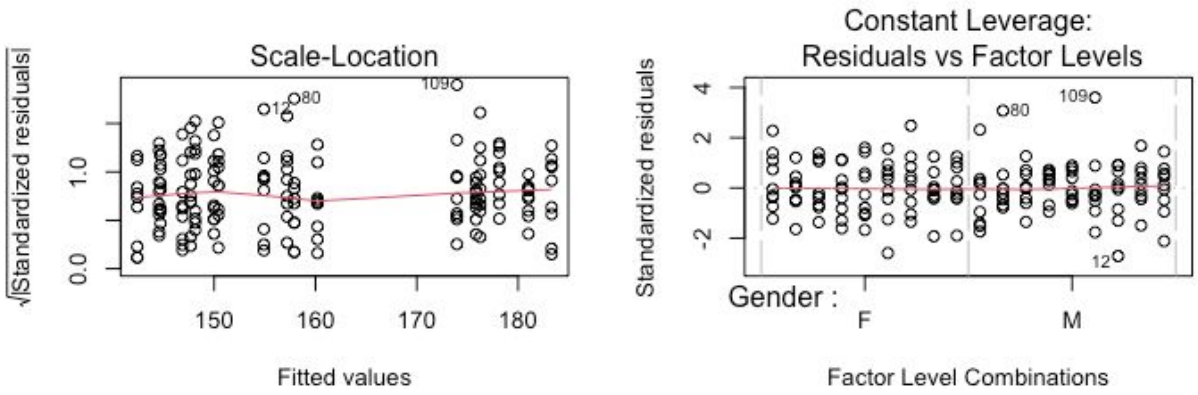
effect of music genre: γ_j for j = 1, 2, 3

effect of age: β_k for k = 1, 2, 3

effect of interaction between gender and music: $(\alpha\gamma)_{ij}$

effect of each individual: ϵ_{ijkl} for l = 1, . . . , 9





Considering the results above, we conclude that the conditions of constant variance and normality of residuals are satisfied. Additionally, there do not appear to be any significant bad leverage points nor outliers.

Discussion

Exploratory Analysis

By first conducting an exploratory analysis and constructing boxplots of pain threshold across our design and blocking factors, we observed that gender and music genre may not have any significant effect on pain threshold. However, the boxplot for pain threshold vs. age group shows a slight difference in mean pain threshold across the three levels, inciting further investigation.

Furthermore, we constructed interaction plots to observe any possible interaction effects between our design factors. We observed that age and music would likely have some interaction - adults have a drastically different trend than youth and seniors - while, age and gender have no interaction. Yet, we do not further investigate age's interaction effects since it is a blocking factor. However, we are interested in gender and music's interaction and initially hypothesize that there is a significant interaction between them. Listening to heavy metal music seems to

heighten pain threshold for males more than classical music, while listening to classical music seems to heighten pain threshold for females more than heavy metal music. Since the mean pain threshold for both classical and heavy metal music are greater than the control pain threshold for both genders, we hope to see that music treatment does in fact have a significant effect on the response.

ANOVA Analysis

A two-way ANOVA analysis of our model indicates that our design factors of age and music genre and their interaction are not significant. Their p-values are greater than our significance level of 0.05, meaning that our observed outcomes are not sufficient to reject our null hypothesis -- that age and gender have no effect on pain threshold. The only significant term is the age blocking factor, meaning that the mean pain threshold is different across at least two of the age groups.

Post Hoc Analysis

Lastly, we conduct a post hoc analysis via TukeyHSD to further investigate the effects of age on pain threshold. We can see that the mean pain threshold is different between seniors and adults, and between seniors and youth. More specifically, the mean pain threshold for seniors is greater than both mean pain thresholds for adults and youth. The mean pain thresholds for adults and youth are not significantly different.

Conclusion

Chronic pain impacts a significant proportion of the population and is a serious issue that merits extensive research and study. Based on our reading of current literature on chronic pain trends and treatments, we decided to explore the effect of gender and music type on pain

threshold, while blocking by age. After analyzing our results, we reject our null hypothesis that all three factors of age, gender, and music treatment have no effect on pain threshold. By a two-way ANOVA analysis, we observed that age is the only significant factor that differs in average pain threshold. By a post hoc analysis, we claim that seniors have a higher pain threshold than both adults and youth.

Our study contained certain limitations that would be best improved upon for future research. One is that the islanders did not know how to express their preferences in music. We hypothesize that letting a person listen to their preferred genre may be more impactful than classical or heavy metal music. We would also like to be able to perform a study where participants listen to music at the same time that their pain threshold is measured. Due to limitations of the Island, only one task may be administered at a time. Our study would also be improved if it had a greater sample size, which would increase power and allow us to detect a smaller effect size.

Further research topics can include setting age as a design factor instead of a blocking factor, thus allowing us to observe its interactions with other design factors. Another future study could use a repeated measures design on participants with chronic pain, since our study only measured islanders' thresholds for acute pain. Lastly, it may be promising to investigate the possible interactions between music and today's most common pain treatments.

Works Cited

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