Group 8
Research Study

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1 Introduction

If you are low socioeconomic status (SES), environmental factors have a stronger impact on your cognitive development than genetic factors; if you are high SES, genetic factors have a stronger impact than environmental ones.

(Harden, Turkheimer, & Loehlin, 2007)

Big concept

Research question

In university students, does listening to music affect the arithmetic scores of those who are low SES more than high SES?

We suspect that students in the low SES group will react more positively to classical music, than students in the high SES group.

We suspect that students in the low SES group will react more negatively to heavy metal music, than students in the high SES group.

2 Experimental design

2 RCBD's

~Population:

University students who are 18-24 years old from the two islands of Colmar and Arcadia

~Treatments:

1. Classical music (10 mins)
2. Heavy metal music (10 mins)

~Response variable:

Mental Difficult Arithmetic (4 mins)

~Blocking factors:

1. Socioeconomic status (SES)
   a. Low (bottom 33%)
   b. High (upper 33%)
2. Island
   a. Arcadia
   b. Colmar

Why did we choose?...

- 18-24 years old = university student
  - In 2011, “79% of college students were aged 18-24 last year.” https://www.marketingcharts.com/demographics-and-audiences/men-demographics-and-audiences-36555
- Compare music in relation to cognition
  - “The trion model suggests that music-related activities share underlying neural firing patterns with other cognitive mechanisms in the brain. As such, listening to music may prime neurons for use in other capacities (e.g., spatial performance tasks)” (Wilderman 2013) https://pdfs.semanticscholar.org/1e4b/bf8798fc24ebb35c9a0e0367d2917750c903.pdf
- Colmar and Arcadia island universities
  - Hofn the third university did not have as many individuals in general so we decided to compare the two largest universities for a better sample size.
- Low vs. High SES blocks
  - The incomes listed on the islands website is not representative of people’s income in real life, so we couldn’t pull ranges for low vs. high SES blocks from research
  - Did not choose middle SES in order to see a more dramatic result in how music affects the two SES blocks

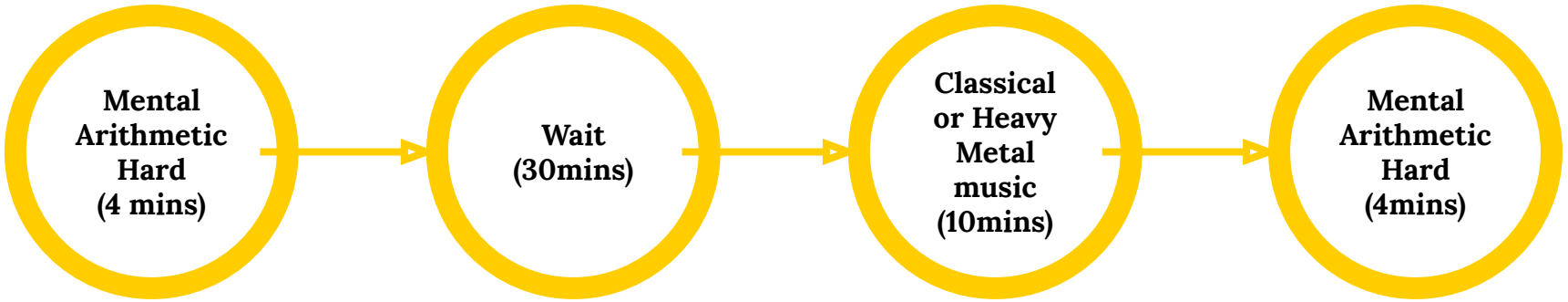
Sampling Method

1. List all university students (ages 18-24) for Arcadia and Colmar and get a sample size using the power test.
2. For each city, take the bottom (and top) 33% of the university student and randomly generate 18 people for the low (and high) SES
3. Randomly assign 2 treatment levels, classical music and heavy metal music

Data Collection Method

1. Pre-test: Take a Mental Difficult Arithmetic test for 4 mins and document their score.
2. Wait for 30 mins.
3. Apply treatment.
4. Post-test: Immediately take Mental Difficult Arithmetic for 4 mins and document their score again.
5. Subtract the pre-test scores from the post-test scores to find the difference.

Data Collection Method



Power of the test

```
library(pwr)
pwr.anova.test(k=2, power=.8, sig.level=.05, f=.5)
```

```
     Balanced one-way analysis of variance power calculation

              k = 2
              n = 16.71472
              f = 0.5
      sig.level = 0.05
          power = 0.8

NOTE: n is number in each group
```

- 17 x 2 = 34 participants
- Currently, we have 34 participants necessary for each island block
- However, we need the same number of observations per block/treatment combination (4)
- Increase to 36 participants for each island block so we can have an equal number of ppl in each combination

Set up

Block 2: Arcadia	Block 1: Low SES	Block 1: High SES
Classical Music	9 participants	9 participants
Heavy Metal Music	9 participants	9 participants

Block 2: Colmar	Block 1: Low SES	Block 1: High SES
Classical Music	9 participants	9 participants
Heavy Metal Music	9 participants	9 participants

We have 9 x 4= 36 people in each island block
Resultant sample size: N=72

Data

Block 2: Arcadia	Block 1: Low SES			Block 1: High SES		
Classical Music	8 4 4	2 2 9	1 3 0	1 3 2	2 1 2	1 3 2
Heavy Metal Music	-4 0 1	-5 -7 -5	-7 -14 -17	-10 -8 -8	-8 -14 -10	-12 -12 -8

Block 2: Colmar	Block 1: Low SES			Block 1: High SES		
Classical Music	-3 15 0	2 3 1	-1 6 7	-1 3 -1	-8 5 4	8 -1 1
Heavy Metal Music	-7 -11 -11	-3 3 -1	-10 -6 -6	-10 -11 -11	-11 -9 -9	-12 -9 -11

3 Results and interpretation

```r
#Colmar:
lm(Score_Difference~factor(Music_Type)+factor(SES), data=colmar) %>% summary
m1 <- aov(Score_Difference~factor(Music_Type)+factor(SES), data=colmar)
summary(m1)
```

```
Call:
lm(formula = Score_Difference ~ factor(Music_Type) + factor(SES),
    data = colmar)

Residuals:
    Min      1Q  Median      3Q     Max
-8.4444 -2.0833 -0.9444  2.1389 12.1111

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                   0.4444     1.3038   0.341   0.7353
factor(Music_Type)Heavy Metal -10.1111     1.5054  -6.716 1.19e-07 ***
factor(SES)Low                 3.5556     1.5054   2.362   0.0242 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 4.516 on 33 degrees of freedom
Multiple R-squared:  0.6057,    Adjusted R-squared:  0.5818
F-statistic: 25.34 on 2 and 33 DF,  p-value: 2.146e-07

                   Df Sum Sq Mean Sq F value   Pr(>F)
factor(Music_Type)  1  920.1   920.1  45.109 1.19e-07 ***
factor(SES)         1  113.8   113.8   5.578   0.0242 *
Residuals          33  673.1    20.4
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Colmar model & ANOVA table

$$\text{Music\_Type} = \begin{cases} 1 \text{ if Heavy Metal Music} \\ 0 \text{ if Classical Music} \end{cases}$$

$$\text{SES} = \begin{cases} 1 \text{ if Low} \\ 0 \text{ if High} \end{cases}$$

Linear model:

Score_Difference = 0.44 - 10.11*Music_Type + 3.56*SES

```r
#Arcadia:
lm(Score_Difference~factor(Music_Type)+factor(SES), data=arcadia) %>% summary
m2 <- aov(Score_Difference~factor(Music_Type)+factor(SES), data=arcadia)
summary(m2)
```

```
Call:
lm(formula = Score_Difference ~ factor(Music_Type) + factor(SES),
    data = arcadia)

Residuals:
     Min       1Q   Median       3Q      Max
-10.1111  -1.3611  -0.1111   1.5556   7.8889

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                    1.444      1.008   1.433   0.1612
factor(Music_Type)Heavy Metal -11.000      1.164  -9.452 6.51e-11 ***
factor(SES)Low                 2.667      1.164   2.291   0.0285 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.491 on 33 degrees of freedom
Multiple R-squared:  0.7414,    Adjusted R-squared:  0.7257
F-statistic:  47.3 on 2 and 33 DF,  p-value: 2.038e-10


                  Df Sum Sq Mean Sq F value   Pr(>F)
factor(Music_Type)  1 1089.0  1089.0  89.346 6.51e-11 ***
factor(SES)         1   64.0    64.0   5.251   0.0285 *
Residuals          33  402.2    12.2
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Arcadia model & ANOVA table

$$\text{Music\_Type} = \begin{cases} 1 \text{ if Heavy Metal Music} \\ 0 \text{ if Classical Music} \end{cases}$$

$$\text{SES} = \begin{cases} 1 \text{ if Low} \\ 0 \text{ if High} \end{cases}$$

Linear Model:

$$\text{Score\_Difference} = 1.44 - 11 * \text{Music\_Type} + 2.67 * \text{SES}$$

ANOVA table when combine data points in Colmar & Arcadia

```
#full model
m1 <- aov(Score_Difference~factor(Music_Type)+factor(SES)+factor(Location))
summary(m1)

#reduced model
m2 <- aov(Score_Difference~factor(Music_Type)+factor(SES))
summary(m2)
```

Full Model

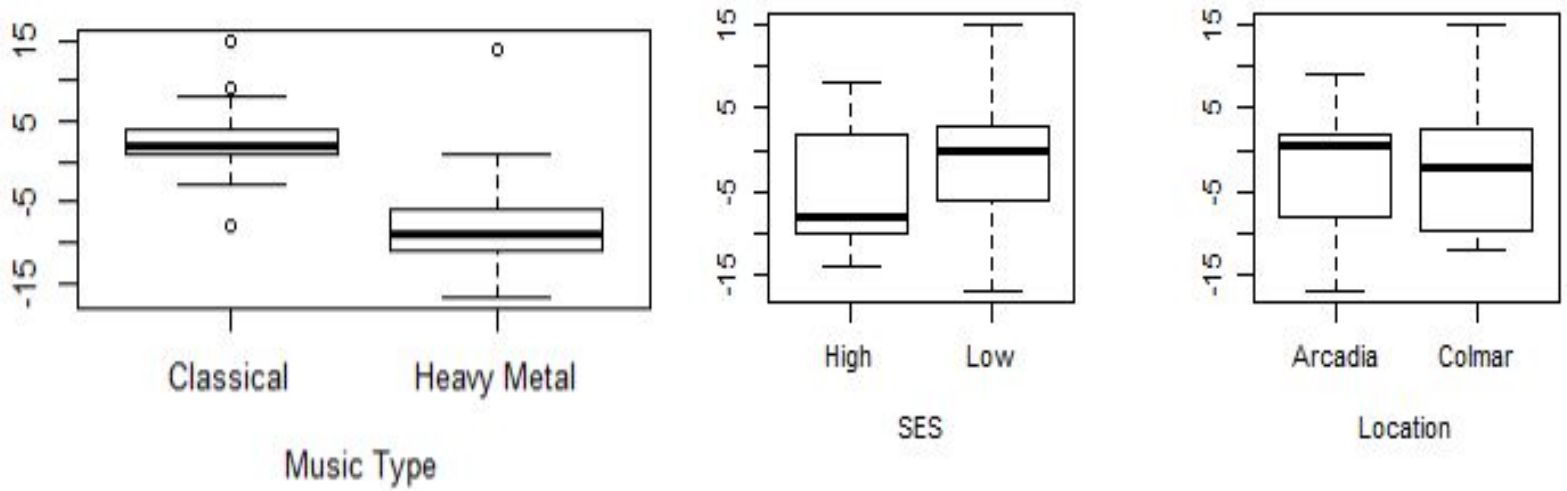
```
                    Df Sum Sq Mean Sq F value Pr(>F)
factor(Music_Type)   1 2005.6  2005.6 125.991 <2e-16 ***
factor(SES)          1  174.2   174.2  10.945 0.0015 **
factor(Location)     1    0.2     0.2   0.014 0.9063
Residuals           68 1082.4    15.9
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Reduced Model

```
                    Df Sum Sq Mean Sq F value  Pr(>F)
factor(Music_Type)   1 2005.6  2005.6   127.8 < 2e-16 ***
factor(SES)          1  174.2   174.2    11.1 0.00139 **
Residuals           69 1082.7    15.7
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Boxplots

Treatments' effect and blockings' necessity



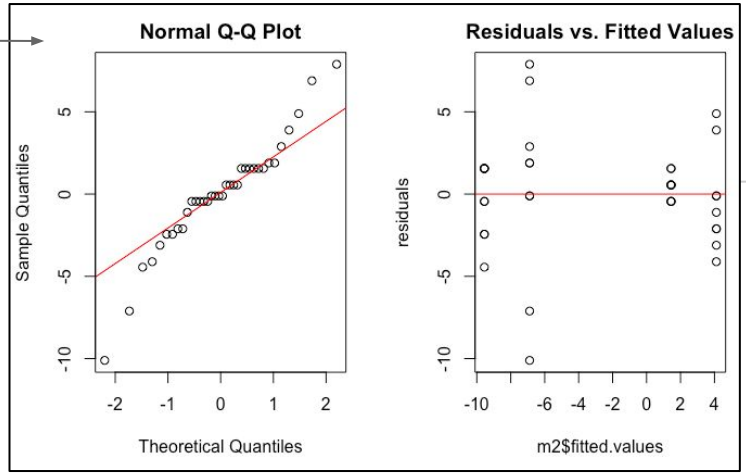
Graphically, the mean test performances between treatments and SES levels appear pretty different. Location doesn't seem to be a major determinant of the test performance.

Model Adequacy

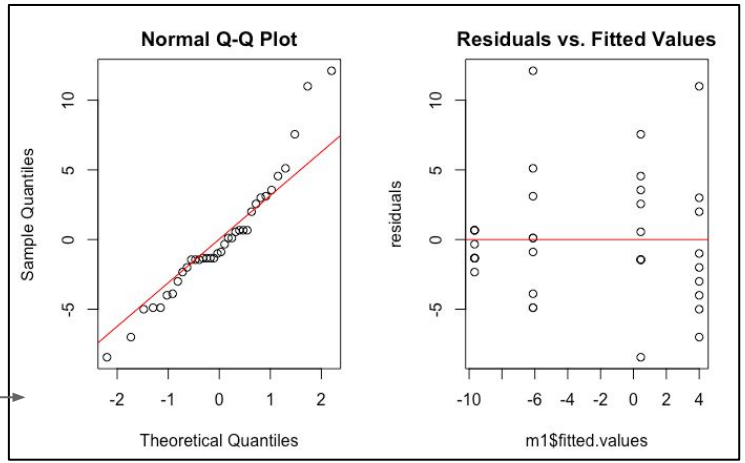
In both university locations,

- The data points approximate the normal qq-plot line of normality, so we meet the normality assumption.
- There is no apparent pattern in the residuals versus fitted values plot, so we meet the assumption of variance constancy

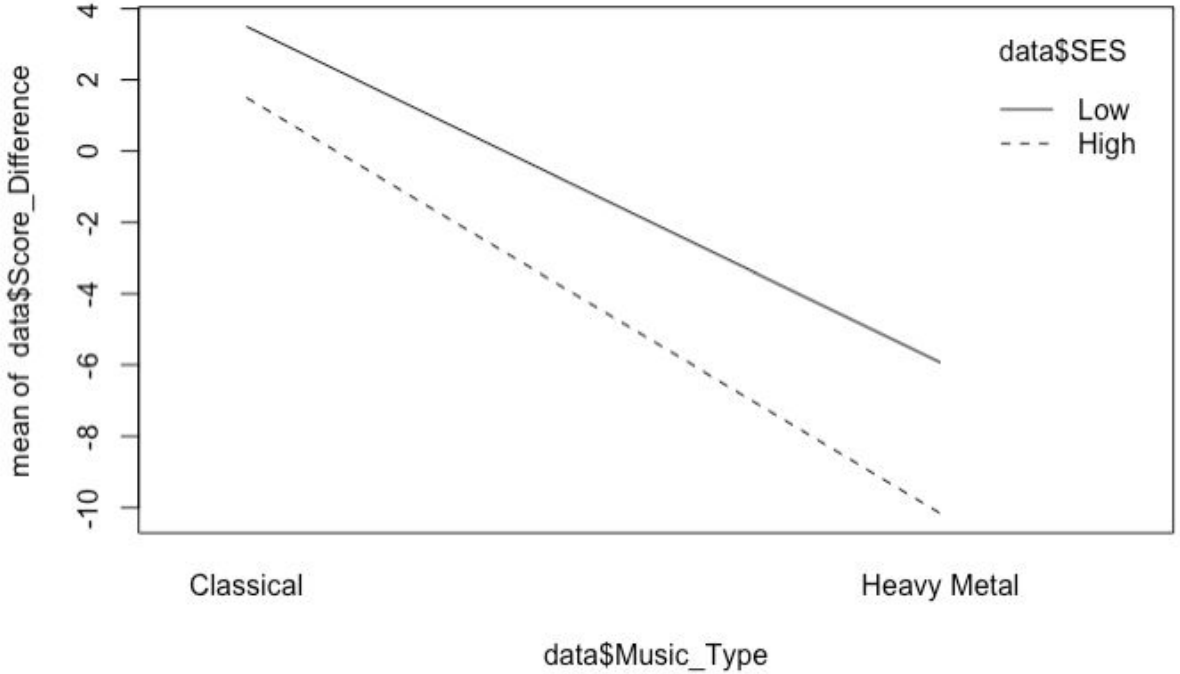
Colmar



Arcadia



Interaction Plot



- No interaction or very minimal interaction occurs between Music_Type and SES
- Students from a low SES react more positively to classical music, but react don't react as negatively to heavy metal music
- Students from a high SES don't react as positively to classical music, but react more negatively to heavy metal music

Result

- In both university locations, the Music_Type and SES were statistically significant at a significance level of 0.05, so we reject the null hypotheses that state Music_Type and SES test performance are the same. This means that at both universities, the Music_Type and SES levels do influence the performance outcome of students on a mental arithmetic test.
- Location of students does not affect their test scores.
- Since the model coefficient for factor(Music_Type)Heavy Metal is around -10 for both university locations, we can conclude that listening to Heavy Metal music before an arithmetic test really negatively impacts testing performance
- The model coefficient for when Music_Type is classical music is not as large in scope as the heavy metal, so we conclude that listening to classical music seems to improve testing performance, but this is not strongly supported.

4 Discussion

In summary...

- The result of our experiment supports our suspicion that music and your SES affects your performance on an arithmetic test.
  - Listening to heavy metal music almost always lowered the scores
- Students from a low SES seem to react more positively to “good” environmental stimuli (classical music), but react don’t react as negatively to “negative” environmental stimuli (heavy metal music)
- Students from a high SES don’t seem to react as positively to “good” environmental stimuli (classical music), but instead react more negatively to “negative” environmental stimuli (heavy metal music)

Limitations

- **Determining SES**
  - Not certain about which SES/economic model the website uses, requiring us to approximate the model
  - Did not consider combined household income (student+parents+spouse)
- **Arithmetic test**
  - Our experiment is only applicable to arithmetic performance and cannot be generalized to other performance tests
- **Human error**
  - When collecting the data, we may not have applied the arithmetic test immediately after giving the treatment, resulting in variation of data
- **Island Restrictions**
  - In real life, other experiments had subjects listening to classical music during testing, we're unable to do that due to the design of The Island

Thanks!

Any questions ?