BA830

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Introduction

Many people listen to music on a regular basis, and research has shown that it significantly affects emotions, mood, and cognition. One cognitive domain that has been investigated in relation to music is short-term memory, which is the brief storage and manipulation of information in the brain for a few seconds to a minute.

This project seeks to investigate the impact of music on short-term memory, specifically whether music influences memory performance. In this experiment, we examine the effects of music with and without lyrics on short-term memory performance.

To accomplish this goal, we conducted a study with 90 participants to see if listening to music affects their short-term memory performance. Two short-term memory tests were administered to participants. The first test was designed to assess their baseline short-term memory performance, while the second was designed to assess their short-term memory performance in response to different treatments. Finally, across all three groups, the differences between the two tests within each group were compared.

Research Question

To what extent does listening to music affect the short-term memory?

Hypothesis

Listening to music while working on short-term memory affects memory performance compared to no music. Different types of music may have varying effects on short-term memory performance.

Methodology

Randomization

To ensure proper randomization, we used Python to generate a list of 120 integer numbers ranging from 1 to 3, with an equal occurrence of 40 times each. We filled in the names of participants chronologically and sent them the corresponding survey link (1 = control, 2 = treatment arm 1, 3 = treatment arm 2).

Experiment Procedure

Participants in the survey are asked to provide their background information and to complete two sets of short-term memory tests. For each test, they are shown a video that sequentially displays 10 words, each for 3 seconds. Following the conclusion of the video, participants were asked to type the words they remembered into the provided text box.

Participants

Our participants are mostly between the ages of 18 and 28. We used social media to reach out to our personal contacts with surveys. Prior to taking the test, participants were asked to provide demographic information such as age, gender, and education level, as well as information about their music preferences such as music-listening habits and preferred genres. As our final input for further data analysis, we collected a total of 90 responses across all three surveys: 30 for the control group, 30 for the first treatment group, and 30 for the second treatment group.

Experiment Design

Our experiment includes three surveys: one control group and two treatment groups. Each survey includes two videos that show words for participants to remember, each followed by a test to see if they can recall the words they just saw. The first video is the same across all three surveys, assessing participants' baseline short-term memory performance. The words shown in the second test are the same for all participants; however, the control group is assigned a video without music, treatment group 1 is assigned an instrumental version of the song (no lyrics), and treatment group 2 is assigned an original version of the song with lyrics.

Short-term memory principle allow for a maximum duration of 30 seconds. As a result, we selected ten words at random to appear in each 30-second video. When designing the experiment, the choice of word difficulty is also taken into account to ensure that the participant's English ability does not interfere with their memorization and recall ability.

To eliminate the effect of memory baseline discrepancies between the control and treatment groups, this experiment is set up as a difference-in-differences analysis.

Data Analysis

Variable Explanation

Column Name	Explanation	Value
Gender	Gender of each participate	Integer, 1 = Male, 2 = Female
Music_lover	To what extent does the participate identify themselves as a music lover	Integer, on scale of 0 to 10, 0 = not at all, 10 = very much
Music_StuWork	To what extent does the participate love to listen to music while study	Integer, on scale of 0 to 10, 0 = not at all, 10 = very much
Correct_words_1	The number of correct words for the first video	Integer, on scale of 0 to 10
Correct_words_2	The number of correct words for the second video	Integer, on scale of 0 to 10
Treatment	The group assignment that participants receive	"control": no music "treatment1": instrumental music "treatment2": lyrical music

Data Cleaning

Across all three surveys, 117 responses were initially received: 40 for the control group, 36 for the first treatment group, and 41 for the second treatment group. We discovered that some data entries cannot be used for the next stage of analysis after reviewing the raw data. It contains blank records and unfinished surveys. We eventually collected 90 valid responses, with 30 records in each group, after filtering out null responses with Python and meeting the sample size goal. In our experiment, words with typos were not considered correct when counting the number of correct words recalled by participants. In our experiment, words with typos were considered incorrect and did not contribute to their successful recall. This is done to avoid being identified.

Regression Analysis

Outcome variable

The percentage difference in the number of words recalled between Test 1 and Test 2, (Test 2 result - Test 1 result)/Test 1 result.

As seen in the table below, only treatment arm 2 shows a significant result when compared to the control group. This indicates that music with lyrics has a negative and significant

impact on short-term memory performance. The difference in Treatment 2 is approximately -0.2980.

```
reg_word_tr_pct <- feols(correct_improvement_pct ~ Treatment,
                     data = All_Cleaned,
                     se = 'hetero')
etable(reg_word_tr_pct)
```

```
                           reg_word_tr_pct
Dependent Var.:     correct_improvement_pct

Constant                       0.1180 (0.1110)
Treatmenttreatment1           -0.0538 (0.1299)
Treatmenttreatment2          -0.2980* (0.1264)
-------------------- ------------------------
S.E. type            Heteroskedasticity-rob.
Observations                              90
R2                                   0.07808
Adj. R2                              0.05688
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Covariates Analysis

After incorporating various covariates, we discovered that treatment arm 2 remains significant. This suggests that listening to music with lyrics continues to have a negative impact on short-term memory performance.

```
reg_word_tr <- feols(correct_improvement_pct ~ Treatment
                     + Music_lover
                     + Music_StuWork
                     + Gender,
                     data = All_Cleaned,
                     se = 'hetero')
etable(reg_word_tr)
```

```
                              reg_word_tr
Dependent Var.:     correct_improvement_pct

Constant                       0.3527 (0.5935)
Treatmenttreatment1           -0.0310 (0.1200)
```

```
Treatmenttreatment2       -0.2722* (0.1114)
Music_lover                -0.0163 (0.0533)
Music_StuWork              -0.0074 (0.0173)
Gender                     -0.0532 (0.0999)
------------------- ----------------------
S.E. type           Heteroskedasticity-rob.
Observations                            90
R2                                 0.08858
Adj. R2                            0.03433
---
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Statistical Power

We evaluated the statistical power of our experiment for the two treatment groups. Based on their respective Average Treatment Effects (ATE), the statistical power for treatment arm 1 and 2 is approximately 0.07 and 0.61. To achieve a statistical power of 0.8 for both treatment groups, we would need sample sizes of approximately 1355 and 46, respectively.

```
pwr.t.test(n = 30, d = d_1, sig.level = .05, power = NULL)
```

```
     Two-sample t test power calculation

              n = 30
              d = 0.1077098
      sig.level = 0.05
          power = 0.06949815
    alternative = two.sided

NOTE: n is number in *each* group
```

```
pwr.t.test(n = NULL, d = d_1, sig.level = .05, power = .8)
```

```
     Two-sample t test power calculation

              n = 1354.049
              d = 0.1077098
```

```
      sig.level = 0.05
          power = 0.8
    alternative = two.sided

NOTE: n is number in *each* group
```

```
pwr.t.test(n = 30, d = d_2, sig.level = .05, power = NULL)
```

```
     Two-sample t test power calculation

              n = 30
              d = 0.5865373
      sig.level = 0.05
          power = 0.6079555
    alternative = two.sided

NOTE: n is number in *each* group
```

```
pwr.t.test(n = NULL, d = d_2, sig.level = .05, power = .8)
```

```
     Two-sample t test power calculation

              n = 46.60956
              d = 0.5865373
      sig.level = 0.05
          power = 0.8
    alternative = two.sided

NOTE: n is number in *each* group
```

Checking for proper randomization

Since the p-value is greater than 0.05, we fail to reject the null hypothesis that the randomization is successful.

```
prop.test(30, nrow(All_Cleaned), 1/3)
```

```
    1-sample proportions test without continuity correction

data:  30 out of nrow(All_Cleaned), null probability 1/3
X-squared = 8.4145e-31, df = 1, p-value = 1
alternative hypothesis: true p is not equal to 0.3333333
95 percent confidence interval:
 0.2445351 0.4357768
sample estimates:
        p
0.3333333
```

Data visualization

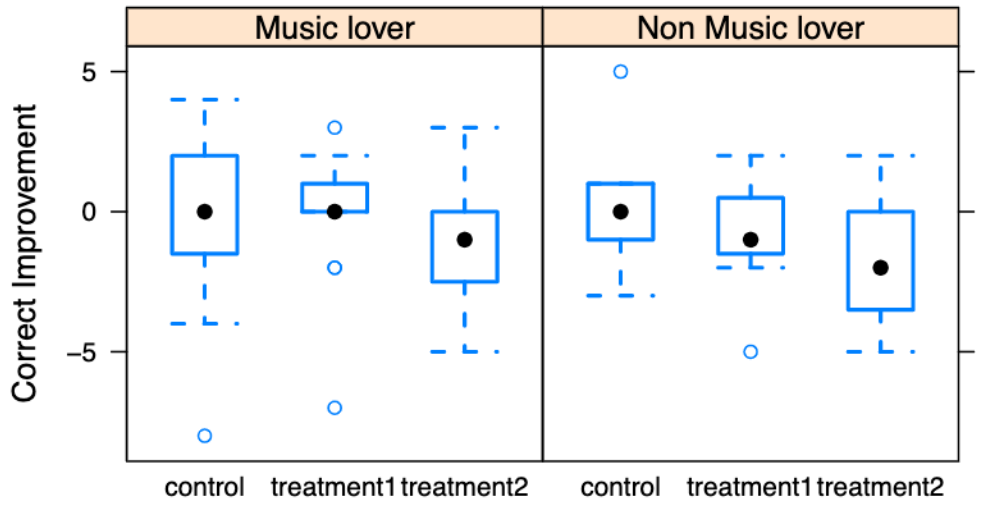
Music lovers vs non music lover

From the previous analysis, we know that music has a significant impact on short-term memory (STM) performance. We further investigated this by examining the participants' characteristics to understand how music affects them.

We divided the participants into music lovers and non-music lovers based on their self-identification as music lovers (a score of 8 and above is defined as a music lover in this case). Our findings suggest that people who are not music lovers are negatively affected by music more than those music lovers. This is reasonable, as individuals who are not accustomed to listening to music might find it more distracting than those who are music lovers.

```r
thickBoxSettings <- list(box.rectangle=list(lwd=2),
                         box.umbrella=list(lwd=2))

bwplot(correct_improvement ~ Treatment|Music_loviness,
       data = All_Cleaned_Loviness,
       par.settings = thickBoxSettings,
       main = " Effect of Music on STM: Music Lovers vs Non-Music Lovers ",
       ylab = "Correct Improvement"
       )
```



Group memorization results

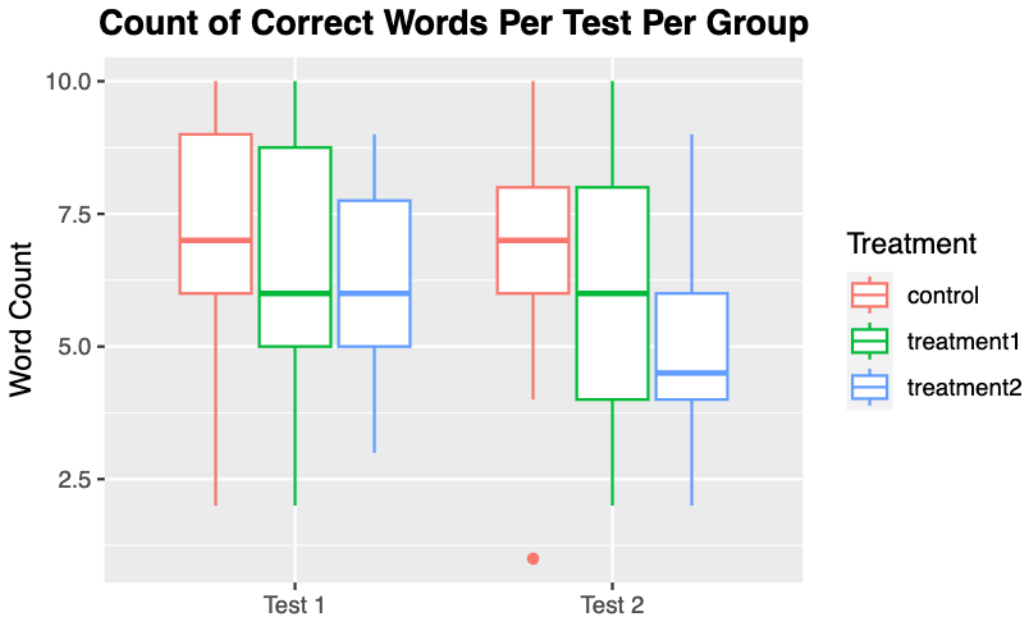
The plot below demonstrates that music with lyrics (Treatment 2) does have an impact on participants' short-term memory performance. While the distributions of the control group and Treatment 1 between the two tests are similar, the median number of correctly recalled words decreases in the second test of Treatment 2.

```
accuracy_comparison = subset(All_Cleaned, select = c(Correct_words_1,
                                                     Correct_words_2,
                                                     Treatment))

accuracy_comparison_melt <- melt(accuracy_comparison,
                                 id = "Treatment")

word_count_plot <- ggplot(accuracy_comparison_melt,
                          aes(x = variable, y = value, color = Treatment)) +
  geom_boxplot() +
  labs(title = "Count of Correct Words Per Test Per Group",
                        y = "Word Count", x = "")  +
  scale_x_discrete(labels = c("Test 1", "Test 2")) +
  theme(plot.title = element_text(face = "bold", hjust = 0.5))

word_count_plot
```



Limitation and Improvement

There are some limitations to our experiment. Due to time and space constraints, we still require more people to participate in our experiment. There were only 30 people left in each group, with the majority of them being between the ages of 18 and 28. Our team may invite more young and older people to participate in order to improve the experiment's accuracy.

Our team could also experiment with different types of music to see how they affect the short-term memory process. Even though our results showed a significant difference between the control and treatment groups, this could also be due to people's sensitivity to hip-hop music. As a result, our team would like to investigate more other types of music, such as classical, R&B, and so on, to see if music still has an effect on short term memory.

Conclusion

In conclusion, the purpose of this study was to examine the effects of music, namely music with and without lyrics, on short-term memory performance. A control group and two treatment groups were part of our study setup. We gathered replies from 90 participants, and after analyzing the data, we discovered that listening to music with lyrics (Treatment 2) significantly improved short-term memory function.

However, our experiment had some limitations, including a small sample size and the majority of participants being between the ages of 18 and 28. We could broaden the age range of our participants and increase the sample size to improve the accuracy of our findings. Future research

could also look into the effects of different music genres on short-term memory performance to further investigate the link between music and memory.

Our findings add to our understanding of how music, particularly music with lyrics, can affect short-term memory performance. This information may be beneficial to educators, students, and professionals who want to improve their learning and working environments.

References

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Appendix

1_Control_NoMusic : https://bostonu.qualtrics.com/jfe/form/SV_ctZwwO6uj6ms570

2_Treatment_NoLyircs: https://bostonu.qualtrics.com/jfe/form/SV_9LDF9ILxpap6t82

3_Treatment_WithLyrics: https://bostonu.qualtrics.com/jfe/form/SV_5gKOywX9Gytsyxg