The Rhythm of Dining; Gauging the Impact of Music on Student Behavior

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1. Introduction

This experimental investigation aimed to evaluate the influence of music on customer behavior in the Einstein's Bros. Bagels cafe. Participants were graduate and undergraduate students from Boston University, aged 16 to 40 years, randomly assigned to either the treatment or control group. The treatment group was subjected to music, consisting of approximately three songs, played for 10 minutes while in the cafe. On the other hand, the control group was not exposed to any music for the same time period. Both groups were closely monitored to assess the impact of music on their decision to sit in the coffee shop.

This experiment followed the Switchback strategy. The study outcomes revealed that the treatment group showed a greater inclination to stay in the cafe than the control group. Specifically, the treatment group exhibited signs of music enjoyment by singing along, humming the melodies, and even dancing, while the control group showed no significant response. These findings imply that incorporating music in the cafe may significantly influence the customers' decision to dine in or not. This study has important implications for the cafe business, which aims to enhance revenue and attract more customers to spend longer duration in their coffee shops.

2. Aim

This experiment aims to examine the impact of music in an on-campus cafe on student behavior. The purpose is to determine whether the presence of music in the cafe would influence the student's decision to remain seated and dine or leave the premises.

3. Motivation

As university students who regularly consume meals on campus, we observed an intriguing aspect of the campus food establishments. Despite not being intended as study areas, they lacked the ambiance of a traditional cafe, particularly the absence of background music. This observation triggered our curiosity to investigate the impact of music on students' behavior. Therefore, we were motivated to explore how music influences students' dining behavior, specifically whether it would encourage them to remain seated and dine, or take their meals to-go. Subsequently, we obtained the necessary permissions and conducted our study in the 'Einstein Bros. Bagels' coffee and bagel cafe on the Boston University central campus.

```
#Loading the 3 csv files
#Converting the 'Yes' & 'No' entries to binary (0/ 1)
ds1 <- fread("d1.csv")
ds1[,binary_outcome := ifelse(outcome == "Yes", 1,0)]
ds1[,binary_gender := ifelse(gender == "Male", 1,0)]
```

```
ds2 <- fread("d2.csv")
ds2[,binary_outcome := ifelse(outcome == "Yes", 1,0)]
ds2[,binary_gender := ifelse(gender == "Male", 1,0)]

ds3 <- fread("d3.csv")
ds3[,binary_outcome := ifelse(outcome == "Yes", 1,0)]
ds3[,binary_gender := ifelse(gender == "Male", 1,0)]

#Binding into one dataset
data <- rbind(ds1, ds2, ds3)
```

4. Experiment

Einstein Bros. Bagels is a cafe situated in the College of Arts and Science (CAS) building at Boston University. The establishment operates from Monday through Thursday, opening at 7:30 am, closing at 8:00 pm, and from 7:30 am to 2:00 pm on Fridays. The cafe's menu comprises an extensive range of food options, including bagels, sandwiches, shmears, and desserts, such as cinnamon rolls, muffins, pastries, and cookies. Additionally, it serves various beverages, such as coffee, tea, shakes, and more. The experiment followed the Switchback strategy over three days:

- Wednesday (03/01/2023): 3:30pm to 8pm
- Thursday (03/02/2023): 12pm to 8pm
- Friday (03/03/2023): 12pm to 3:30pm

The experiment exposed all the students in the cafe to music for a 10-minute period, and the subsequent 10-minute period was controlled without music. There was a 5-minute freeze time where no data was recorded. There were an odd number of switches each day, ensuring the rush hour on day one was in treatment and in control the next day. Music was played through a speaker centrally placed in the cafe. Music was selected from the worldwide top trending songs to ensure student engagement.

4.1 Unit of Randomization: Time-stamp

5. Analysis

5.1 Ggplot

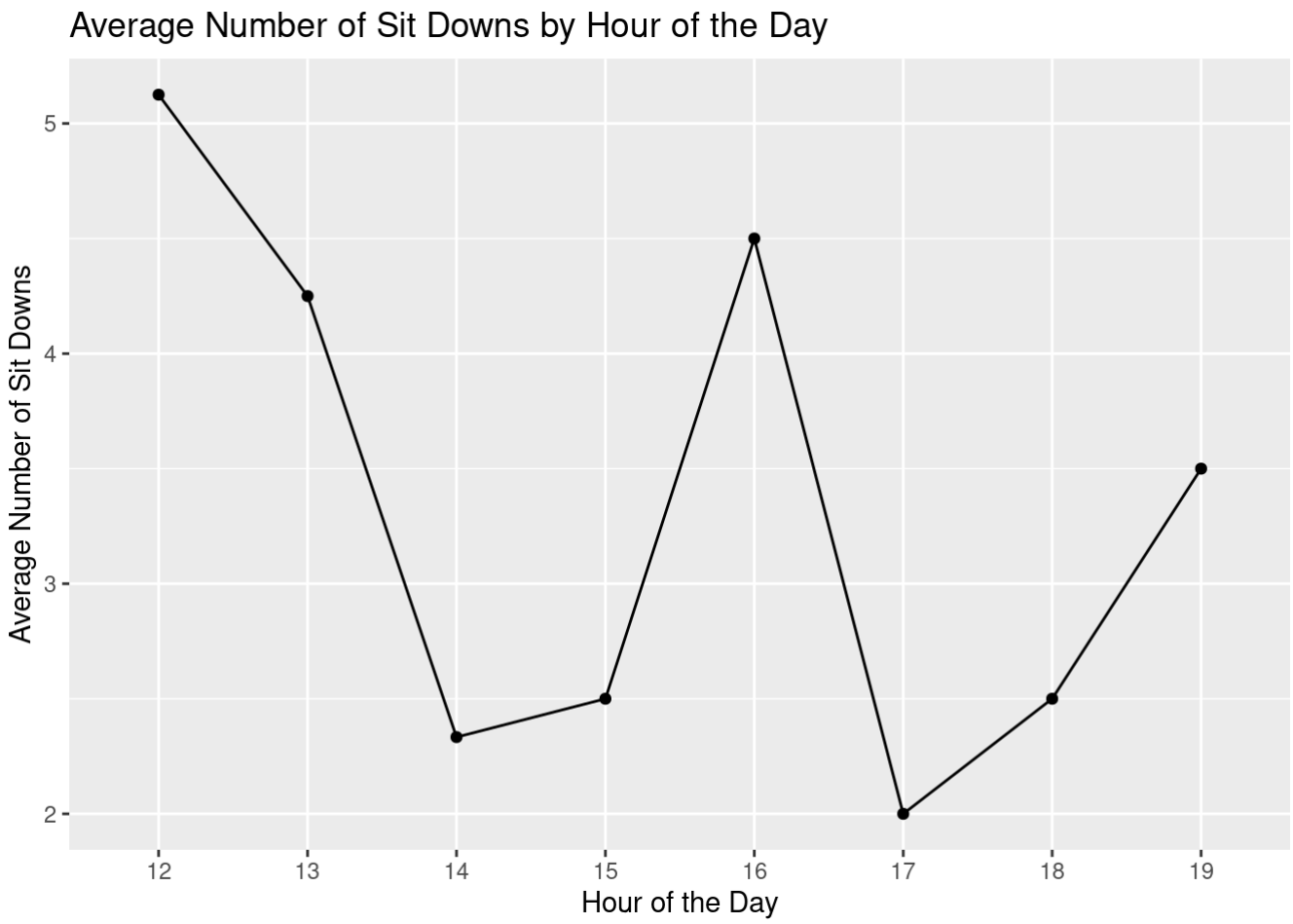
Used ggplot to visualize the rush hours in the cafe. The graph was plotted with the average number of student sit-downs against the hour of the day.

5.1.1 Calculating the Average Sit Down Rate as a function of time of the day

```
data$time <- as.POSIXct(data$time, format = "%m-%d-%Y %H:%M")
#Creating a new column for hour
data$hour <- format(as.POSIXct(data$time,
                               format = "%m/%d/%Y %H:%M"),
```

```
                    format = "%H")
#Creating a new dataset
data_summary <- data %>%
  group_by(time) %>%
  summarize(total_sit_down = sum(binary_outcome))
```

```
data$time <- as.POSIXct(data$time, format = "%m-%d-%Y %H:%M")
#Creating a new column for hour
data_summary$hour <- format(as.POSIXct(data_summary$time,
                                format = "%m/%d/%Y %H:%M"),
                            format = "%H")
#Creating a new dataset
data_summary2 <- data_summary %>%
  group_by(hour) %>%
  summarize(avg_sit_down = mean(total_sit_down))
```

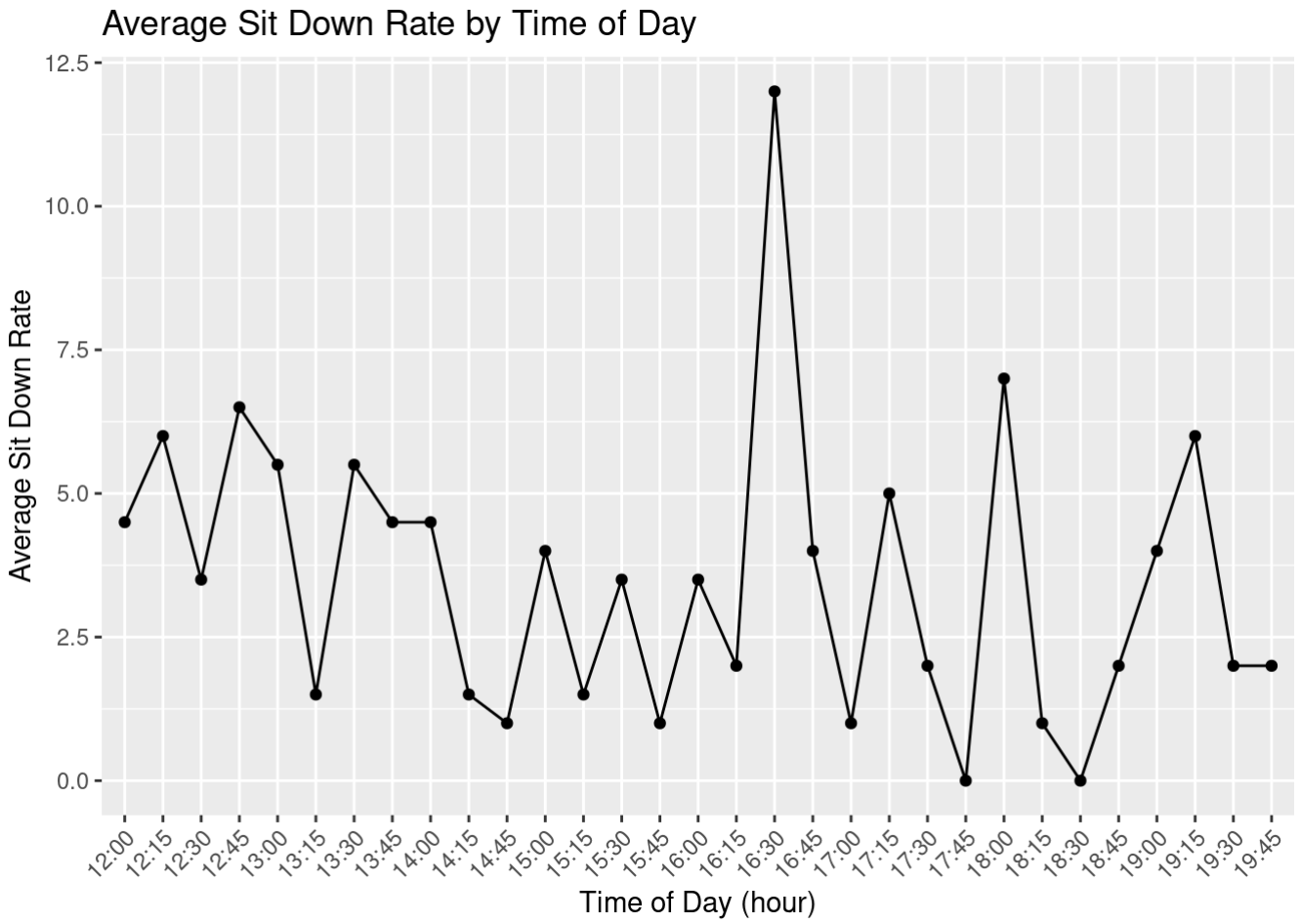


Result

On plotting the average number of sit downs vs hours of the day, , it was recognized that the majority of classes in the Cass building were dispersed around noon, causing an influx of students into the cafe. The next peak is at 4pm, which is when the majority of classes are dispersed. Interestingly, the peak at 7pm was majorly due to faculty, staff, and students sitting down for dinner.

5.1.2 Calculating the Average Sit Down Rate as a function of time of the day

```
#Creating a new column for hour
data_summary$time_stamp <- format(as.POSIXct(data_summary$time,
                                  format = "%m/%d/%Y %H:%M"),
                                  format = "%H:%M")
#Creating a new dataset
data_with_time <- data_summary %>%
  group_by(time_stamp) %>%
  summarize(avg_sit_down = mean(total_sit_down))
```



Result

To gain further understanding of the sit down rate, it was plotted as a function of the unit of randomization, the 15 minute time period. It can be noticed that a significantly high peak was observed for the time frame 4:30pm to 5pm. This was an instance where the cafe reached its maximum capacity, forcing students to resort to other venues to eat their meals. As most classes dispersed during this time, the cafe remained at capacity for an extended period of time beyond this time frame.

5.2 Prop test

To check for randomization, a prop test was conducted for all students who were treated with the total number of students in the experiment.

```
#Total rows
total_count <- nrow(data)
t_total <- sum(data$treatment == 1)
#prop test to check the p-value
p_t <- prop.test(t_total, total_count, p=0.5)
p_t
```

```
    1-sample proportions test with continuity correction

data:  t_total out of total_count, null probability 0.5
X-squared = 0.7, df = 1, p-value = 0.4
alternative hypothesis: true p is not equal to 0.5
95 percent confidence interval:
 0.471 0.576
sample estimates:
    p
0.524
```

Result

Since the 95% confidence interval contain 0.5, it can be concluded that the experiment was properly randomized.

5.3 Extracting the hour, time and date from the time stamp

```
#Adding the hour, time_stamp and date column to the original dataset
#Creating a new column for hour and minute
data$time_stamp <- format(as.POSIXct(data$time,
                                     format = "%m/%d/%Y %H:%M"),
                          format = "%H:%M")
#Creating a new column for date
data$date <- format(as.POSIXct(data$time,
                                     format = "%m/%d/%Y %H:%M"),
                    format = "%m/%d/%Y")
```

5.4 Regression

Using the 'feols' function, regression was done while taking the outcome variable (whether the student sits down or not) against being treated. Since this was a switchback experiment, to understand the effect of fixed effects, date & time were also taken into consideration.

```
#Regression on the outcome variable of
#whether the person sat down or not
reg_1 <- feols(binary_outcome ~ treatment | time_stamp + date,
                data = data, cluster = 'time')
```

```
#Regression on the outcome variable of
#whether the person purchased a coffee or not
reg_2 <- feols(coffee ~ treatment | time_stamp + date,
                data = data, cluster = 'time')
#Regression on the outcome variable of whether
#the person purchased a bagel or not
reg_3 <- feols(bagel ~ treatment | time_stamp + date,
                data = data, cluster = 'time')
#Summary Table
modelsummary(list("Outcome Variable" = reg_1,
                  "Coffee" = reg_2,
                  "Bagel" = reg_3),
             type = 'text',
             stars = T,
             output = 'markdown',
             coef_map = c("treatment" = "Treatment Effect"),
             gof_map = c("nobs", "r.squared"))
```

	Outcome Variable	Coffee	Bagel
Treatment Effect	0.349***	0.057	0.120+
	(0.069)	(0.058)	(0.062)
Num.Obs.	359	359	359
R2	0.166	0.153	0.126

Note: ^^ + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Result

The above regression table indicates that the Average Treatment Effect of playing music in the cafe is 0.349, which is statistically significant. This indicates that students in this on-campus cafe are more likely to sit down at the cafe as a result of the treatment, which is being exposed to music. However, it is also important to note that the treatment does not have a statistically significant effect on the purchase of bagels and coffee. This could be due to the fact that students come into the cafe with the intention of buying their particular order, and the treatment has no effect on that purchase.

5.5 Balance Check

To check for equal proportion of Males and Females in treatment & control group, a balance check was done by taking the ratio of females in treatment versus in control.

```
#Total rows of the entire data
total_count <- nrow(data)
#Treatment Group
t_total <- (data[treatment==1])
x= nrow(t_total)
#Females in the Treatment Group
```

```
female_treatment <- t_total[binary_gender == 0]
y = nrow(female_treatment)
#Ratio of the females
ratio_female_treatment <- y/x
paste("Ratio of Females in the Treatment Group is: ",ratio_female_treatment)
```

```
[1] "Ratio of Females in the Treatment Group is:  0.632978723404255"
```

```
#Total rows of the entire data
total_count <- nrow(data)
#Treatment Group
c_total <- (data[treatment==0])
a= nrow(c_total)
#Females in the Control Group
female_control <- c_total[binary_gender == 0]
b = nrow(female_control)
#Ratio of the males
ratio_female <- b/a
paste("Ratio of Females in the Control Group is: ",ratio_female)
```

```
[1] "Ratio of Females in the Control Group is:  0.502923976608187"
```

Result

The treatment group consisted of 63.3% females and 36.7% males, while the control group consisted of 50.3% females and 49.7% males. This shows that the observations were balanced in terms of gender between the treatment and control groups.

6. Conclusion

After analyzing the data, the conclusion drawn from this study is that there is a statistically significant effect of music on the rate at which customers choose to sit down at the on-campus cafe. This indicates that many students prefer to sit down and potentially spend more time in the cafe when music is being played. However, it was also found that the presence of music does not have a significant effect on the purchasing behavior of these students.

Based on these findings, we can reject the null hypothesis that the presence of music has no effect on student preferences, in favor of the alternative hypothesis.

In summary, this study suggests that playing music in the on-campus cafe can positively impact the sit down rate of customers, but it does not necessarily lead to increased sales.

7. Limitations

7.1 Limited selection of days

The experiment was only conducted on three specific days (Wednesday, Thursday, and Friday) before spring break, which may have introduced bias.

7.2 Limited Number of observations

The experiment only observed 61 time frames of 10 minutes each, with a 5-minute freeze time between treatment and control. More observed time frames could have improved the study's results.

7.3 Limited seating capacity

The cafe's limited seating capacity resulted in many students sitting outside the cafe, despite the intention to observe their behavior inside.

7.4 Limited to a broad range of music

The experiment did not account for the specific genre of music being played, which ranged from hip-hop to indie, Spanish, and country music.

8. Future Scope

The experiment conducted at Einstein Bros. Bagel has the potential for further research to understand students' music preferences and how they impact sit-down rates. Additionally, future studies could investigate if specific music genres cause shifts in purchasing patterns or sales. Moreover, further experiments could be conducted to determine the ideal volume of music for on-campus cafes and restaurants.

This study can also be implemented at other on-campus dining services and lounging areas, including universities outside of Boston University. Another interesting avenue for research would be to examine whether students from different academic disciplines have varying preferences for music versus no music and the type of music being played.

Overall, the study's findings provide a foundation for future research to build upon and expand our understanding of the effects of music in on-campus dining settings.

9. Bibliography

Here are the sources that we referred while conducting this switchback experiment.

- HBS Uber Case
- HBS Publication
- Milk Production Response to Supplementation
- Experiment Rigor for Switchback Experiment Analysis
- Switchback Tests and Randomized Experimentation Under Network Effects at DoorDash
- Temporal Changes in Gene Expression

10. Appendix

10.1 Data-set Description

This experiment was based on an observational data-set, recorded over the course of three days. Data was collected by observing people entering, sitting, or exiting the cafe during the 10-minute window.

The observational desk was set up right in the middle of the bagel shop to prevent data loss. For every individual, the following attributes were recorded:

- **Time-stamp:** Date and time recorded for the students entering the cafe.
- **Treatment/ Control:** Whether the student entered during the treatment or control time period.
- **Gender:** Student's gender (Female, Male).
- **Coffee:** Whether a coffee was ordered.
- **Bagel:** Whether a bagel was ordered.
- **If they sat down:** The outcome variable recording 'Yes' for if the student sat down for their meal.

```
#Visual representation of the data-set
data
```

```
                  time person treatment coffee bagel gender outcome
  1: 2023-03-01 15:30:00      1         1      1     1   Male     Yes
  2: 2023-03-01 15:30:00      2         1      1     0 Female     Yes
  3: 2023-03-01 15:30:00      3         1      0     1   Male     Yes
  4: 2023-03-01 15:30:00      4         1      1     1 Female     Yes
  5: 2023-03-01 15:30:00      5         1      1     0   Male     Yes
 ---
355: 2023-03-03 15:00:00    140         1      1     1 Female     Yes
356: 2023-03-03 15:15:00    141         0      0     1   Male      No
357: 2023-03-03 15:15:00    142         0      0     0   Male      No
358: 2023-03-03 15:15:00    143         0      1     0   Male      No
359: 2023-03-03 15:15:00    144         0      1     1 Female     Yes
     binary_outcome binary_gender hour time_stamp       date
  1:              1             1   15      15:30 03/01/2023
  2:              1             0   15      15:30 03/01/2023
  3:              1             1   15      15:30 03/01/2023
  4:              1             0   15      15:30 03/01/2023
  5:              1             1   15      15:30 03/01/2023
 ---
355:             1             0   15      15:00 03/03/2023
356:             0             1   15      15:15 03/03/2023
357:             0             1   15      15:15 03/03/2023
358:             0             1   15      15:15 03/03/2023
359:             1             0   15      15:15 03/03/2023
```

10.2 Data Grouping

Data-set grouped by hour of the day from noon-8pm. It has 8-hour slots which is then used to estimate the total students who sat down during those hour slots and the subsequent average sit-down rate for those hour slots.

```
data_summary2
```

```
# A tibble: 8 × 2
  hour  avg_sit_down
  <chr>        <dbl>
1 12            5.12
2 13            4.25
3 14            2.33
4 15            2.5
5 16            4.5
6 17            2
7 18            2.5
8 19            3.5
```

Data-set grouped by time of the day from noon-8pm. It has a total of 31 time slots for 15-minutes each which is then used to estimate the total students who sat down during those hour slots and the subsequent average sit-down rate for those time slots.

```
data_with_time
```

```
# A tibble: 31 × 2
   time_stamp avg_sit_down
   <chr>             <dbl>
 1 12:00               4.5
 2 12:15               6
 3 12:30               3.5
 4 12:45               6.5
 5 13:00               5.5
 6 13:15               1.5
 7 13:30               5.5
 8 13:45               4.5
 9 14:00               4.5
10 14:15               1.5
# … with 21 more rows
```

10.3 Unique Hours

Getting an estimate of the total unique time (hour) slots present in the entire data-set.

```
#Unique number of time-slots (hour)
unique(data[, hour])
```

```
[1] "15" "16" "17" "18" "19" "12" "13" "14"
```

```
paste("Unique hours in the dataset: ",uniqueN(data[, hour]))
```

```
[1] "Unique hours in the dataset:  8"
```