Investigating the Combined Effects of Alcohol, Exercise, and Music on Reaction Time

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Introduction:

Our research aims to explore how alcohol consumption, exercise, and the type of music will affect the reaction times within a virtual human population known as "the Islanders." We chose these three factors because drinking alcohol is a common social activity, but its effects on cognitive functions, particularly reaction time, can lead to significant consequences. Exercise is known to enhance reaction times, making it a key factor to investigate. Additionally, the type of music people listen to can influence their mood, potentially impacting reaction time. By understanding how these factors interact and individually influence reaction time, we hope to gain a better understanding of our cognitive function. Ultimately, our goal is to find the best strategies to improve reaction time based on alcohol intake, exercise, and music choice.

Methodology:

Experimental Design:

We will use a 2^3 factorial design in one block factor. We will evaluate the effects of three factors: alcohol (A), exercise (B), and music (C), each at two levels.The levels include no alcohol and consuming 150ml of vodka for factor A, no exercise and a 1km run for factor B, and listening to 10 minutes of heavy metal music versus 10 minutes of classical music for factor C. In addition, we will use a block factor, which is Gender (Male and Female) to control for potential baseline differences in reaction time. Reaction time will be measured using a ruler test, where participants catch a falling ruler, and the distance is recorded. The change in reaction time is calculated by comparing post-treatment reaction times to baseline measurements.

On each of the three islands, we will select 2 males and 2 females aged 20-40, resulting in a total of 6 males and 6 females per run. For each run, we will record their baseline reaction time. Participants will then be randomly assigned to one of the 8 treatment combinations, and the tests will be conducted. The order of performing treatment levels within each combination is also randomized, and there is a 15-minute wait time for consuming vodka in order to let alcohol generate effects. This procedure will be repeated for all 8 treatment combinations, recording the change in reaction time for each.

Data Analysis:

Our Analysis will include An Analysis of Variance (ANOVA) which was used to assess the significance of the main effects (A, B, C) and interaction effects (AB, AC, BC, ABC) on reaction time. ANOVA table will provide us with the p-value which will indicate whether a factor is statistically significant or not. We will also need an effect size table to understand the practical significance of each factor, an interaction plot which helps to interpret how the combined levels of factors influenced reaction time, and a cube plot which identifies the optimal treatment combination for minimizing reaction time. Last but not least, we will need to check the model assumption to make sure the model is unbiased.

Results and Interpretation:

Anova Table:

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
factor(alcohol)	1	660.5	660.5	331.025	< 2e-16	***
factor(exercise)	1	99.6	99.6	49.938	3.73e-10	***
factor(music_type)	1	50.8	50.8	25.437	2.47e-06	***
factor(block)	1	20.0	20.0	10.016	0.00214	**
factor(alcohol):factor(exercise)	1	14.6	14.6	7.303	0.00828	**
factor(alcohol):factor(music_type)	1	3.3	3.3	1.654	0.20180	
factor(exercise):factor(music_type)	1	40.3	40.3	20.199	2.14e-05	***
factor(alcohol):factor(exercise):factor(music_type)	1	10.8	10.8	5.413	0.02231	*
Residuals	87	173.6	2.0			

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Based on ANOVA table, we can see that all three factors and the block factor are significant with p-value less than 0.05. In addition, there is interaction between alcohol and exercise, exercise and music type, and among all 3 factors. The interaction between alcohol and music type is not significant. Since significant interactions exist within the experiment, the significance of single-factor variables should not be easily accepted anymore.

Effects Size Table:

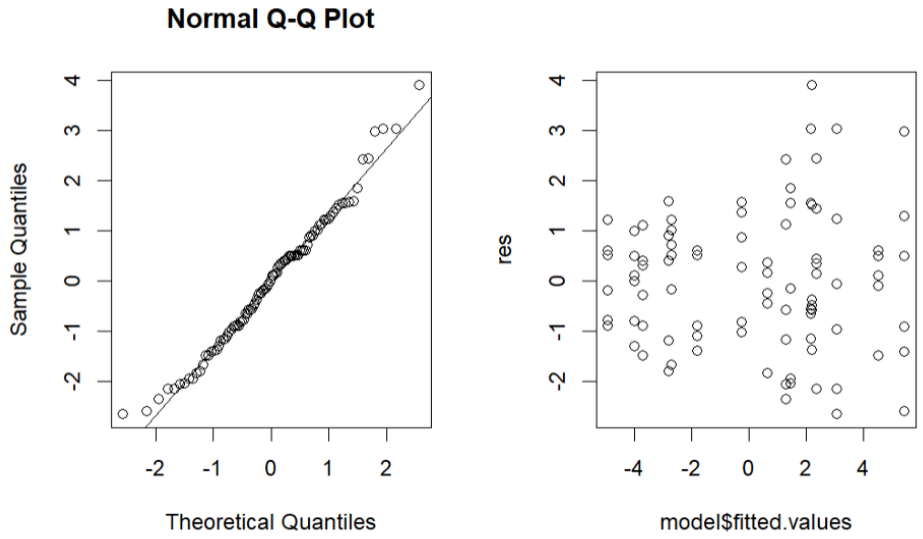
alcohol	exercise	music_type
5.2458333	-2.0375000	-1.4541667
blockmale	alcohol:exercise	alcohol:music_type
-1.8250000	0.7791667	0.3708333
exercise:music_type	alcohol:exercise:music_type	
1.2958333	0.6708333	

The effects table provided effect sizes for each main effect and interaction, quantifying their impact on reaction time.

Main effect: The result shows that **Alcohol (A)** significantly increased reaction time. Participants who consumed alcohol had a slower reaction time compared to those who did not; **Exercise (B)** significantly decreased reaction time. Participants who exercised had a faster reaction time compared to those who did not; heavy metal music **(Music C)** slightly decreased reaction time compared to classical music.

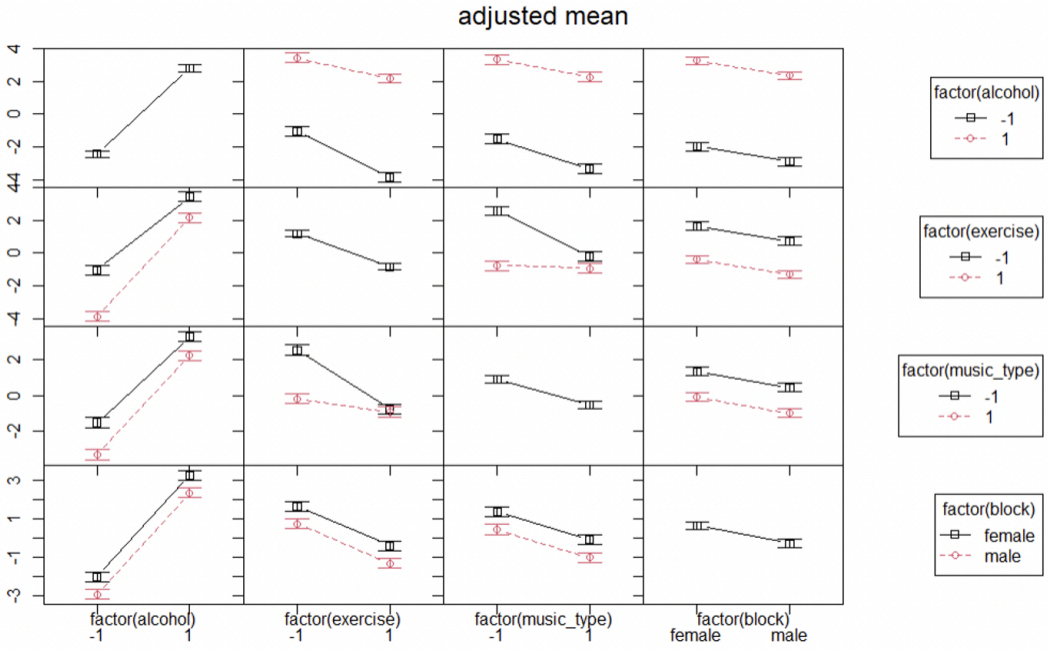
Interaction effect: The interaction between alcohol and exercise showed that exercise mitigated the negative impact of alcohol on reaction time**(AB Interaction)**; the interaction between alcohol and music indicated that listening to heavy metal music slightly offset the reaction time slowdown caused by alcohol**(AC Interaction)**; the interaction between exercise and music showed that the combination of exercise and heavy metal music resulted in the fastest reaction times**(BC Interaction)**; the three-way interaction indicated that the combination of no alcohol, moderate exercise, and heavy metal music produced the lowest reaction times.**(ABC Interaction)**

Assumption Checking:



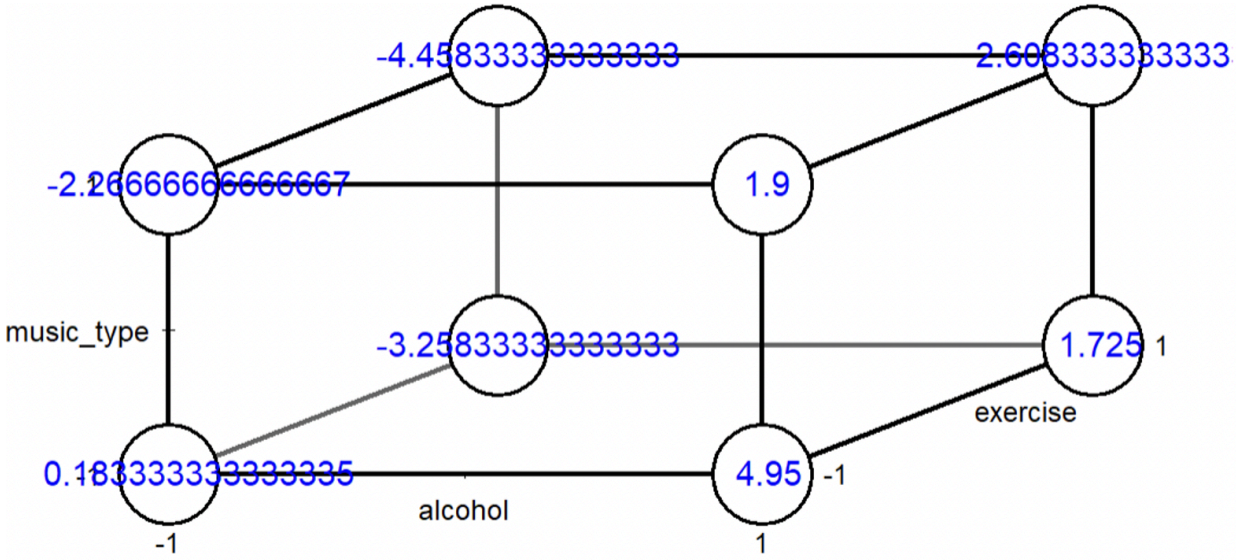
The residuals appeared randomly scattered around zero, indicating that the assumption of equal variance was met. Q-Q plots indicate that the model closely followed a normal distribution, satisfying the normality assumption. There is a little bit of deviation on the head and tail which suggests a slight violation of the assumption of normality.

Interaction graph :

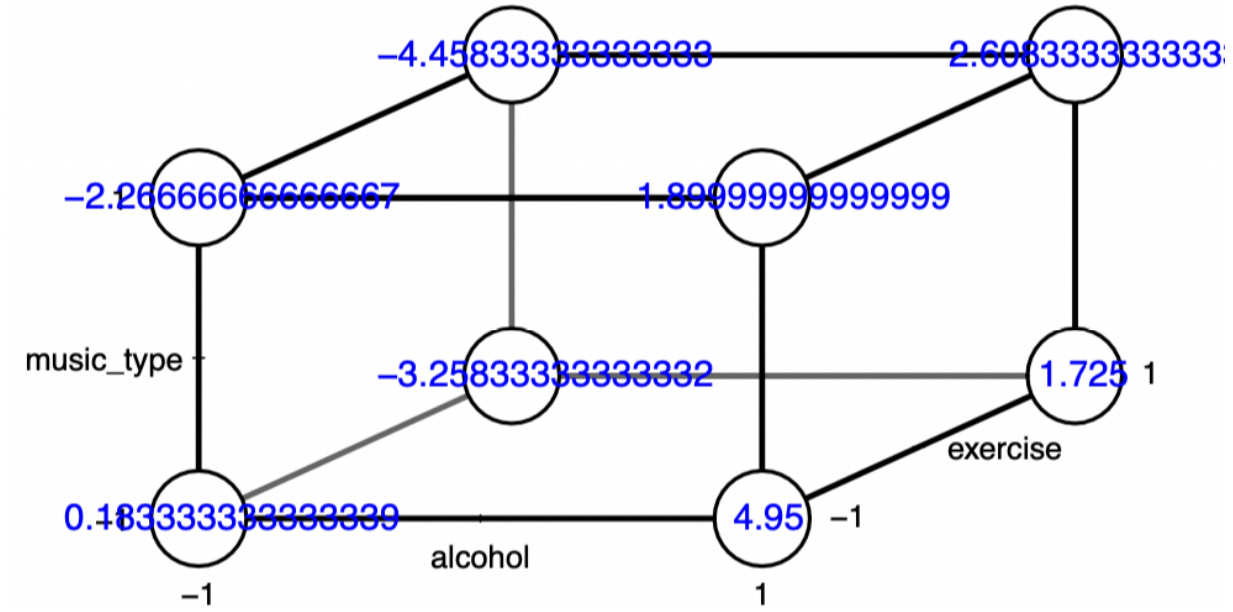


The interaction graph shows that the lines for alcohol and exercise, exercise and music type are non-parallel, which suggests that there is likely an interaction between these factors. Therefore, we can conclude that these interactions are significant, just as what the anova table above indicated. It also shows that a combination of no alcohol assumption, moderate exercise and heavy type of music lowers participants' reaction time the most.

Cube plot with blocking



Cube plot without blocking



Both cube plots with and without blocking shows that the treatment combination of no alcohol, moderate exercise, and listening to heavy metal music(-1, 1, 1) lowers the reaction time the most, which is the same as what we concluded in the interaction plot.

Power test

```
##
##      Balanced one-way analysis of variance power calculation
##
##               k = 8
##               n = 6.660748
##               f = 0.6318816
##       sig.level = 0.05
##           power = 0.9
##
## NOTE: n is number in each group
```

Based on the power test, n = 6.660748 which indicates that approximately 7 samples are required in each group to achieve the desired power of 0.9. The sample size should be n x k = 7 x 8 = 56, while we have n = 12 and a sample size of 96, which will increase the power of our test beyond 0.9, we have a higher probability of detecting a true effect.

Discussion and Conclusion

The study indicates that alcohol, exercise, and the type of music are almost all significantly interacting with each other and impacting the reaction time. To speed up reaction time, it is recommended to not consume alcohol, engage in moderate exercise, while listening to heavy metal music. However, if a participant did consume alcohol, the best strategy to minimize the effect of alcohol is to exercise and listen to classical music.

While this study provides valuable insights, there are a few limitations to consider. First, each individual's reaction times vary significantly, which is hard to control. Factors such as genetics, health, and past experiences contribute to each person's unique baseline reaction time. Second, we focused on participants aged 20-40 and tried to keep their ages between 20-30. However, this is still a broad age range, and age itself can affect reaction times. A narrower age range might have given more consistent results. Lastly, the way we assigned music levels could be improved. Rather than assigning both levels a type of music, it might have been better to have one level where participants didn't listen to music at all. This change would help us better understand how music in general affects reaction times.

The findings of this study have several practical applications, particularly in contexts where quick reaction times are critical. For instance, while driving under the influence of alcohol is illegal and highly discouraged, the knowledge that exercise can mitigate some of alcohol's negative effects on reaction time can be beneficial in other settings, such as social environments. Additionally, athletes can incorporate moderate exercise and high-tempo music into their training to enhance performance, and workplaces can promote short exercise breaks and stimulating music to boost productivity and mental alertness. Individuals in everyday life can also use these strategies to maintain cognitive sharpness and quick reactions, especially in emergency situations. Furthermore, music therapy practices can be informed by these findings, using high-tempo music to enhance alertness and cognitive performance. Overall, integrating

moderate exercise and stimulating music into daily routines can help individuals maintain better cognitive functions and reaction times, contributing to overall safety and productivity.