Combining levels of tea consumption with classical music to investigate temporary cognitive function improvement of university students

Introduction

Students use a variety of techniques to improve their studying ability, with improving cognitive ability for study sessions being valuable. Tea is commonly used and is evidentially supported to increase short term cognitive performance (Rizwan et al., 2017). Classical music, despite being used quite commonly as a possible enhancer, has little conclusive evidence in focus and cognitive performance for students (Wang, 2023).

In practice students may want to combine multiple cognitive enhancing techniques, and this study aimed to analyse how these enhancers work together so students can make a more informed choice of their study strategies. It was found using a two-way ANOVA that tea and music had a strong interaction effect (p = 0.025), that silent participants had a strong increase in performance when drinking tea (p = 0.013), and classical music had no significant effect (p = 0.41).

Method:

This is an experimental study conducted on 36 University of Arcadia students aged 18-30 to reduce possible variability caused by age. The full list of university students was ordered randomly using R. The first 65 students in this randomised list were reached out to, of which 38 were within the correct age range and consented without withdrawing from the study. The final 2 on the list were let go to have equal population among the groups. It was assumed most university students drank caffeine regularly and did not listen to classical music regularly. All students when asked followed this assumption. Hence this sample was deemed representative.

Students were equally divided into classical music and silent groups (denoted α_0, α_1 respectively) to listen to for 10 minutes before the test conducted at noon. They were subdivided to drink 0,2,4 cups of black tea denoted ($\beta_0, \beta_1, \beta_2$ respectively) 30 minutes before the test to allow the tea effects to activate, giving approximately 0mg, 80mg,160mg of caffeine respectively (Rizwan et al., 2017). They performed a simple problem-solving test marked out of 100% to replicate mentally stimulating but not hard study, which was assumed to comprise typical study time.

This study has no ethical concerns as the maximum amount of tea drunk was less than half of the recommended daily maximum of 400mg and was consumed before noon to not negatively affect sleep of participants (Rizwan et al., 2017).

Two-way ANOVA was used with the following model, as the primary goal was to check for an interaction effect between the categorical factors of tea consumption and classical music:

$$T_{ijk} = \mu_{0,0} + \alpha_i + \beta_j + \gamma_{ij} + \epsilon_{ijk}$$

Where for the kth replication where $1 \leq k \leq 6$:

T = test score% as the response variable, where $0 \leq T \leq 100$

$\mu_{0,0}$ denotes the mean of the silent no tea group

Exploratory variables α_i and β_j

γ_{ij} denotes the interaction effect of levels i, j on the response variable

ϵ_{ijk} denotes the residual error for kth replication of level combination i, j, where $\epsilon_{ijk} \overset{iid}{\sim} N(0, \sigma^2)$

For this model to be appropriate, the following were assumed:

Independence of responses, each group had equal variances, each sample followed its group's normal distribution, and the residual errors had a mean of zero.

The following set of null hypotheses were tested:

The Music Null Hypotheses H_0 where $\alpha_i = 0$ for all i, with the corresponding alternative hypothesis $H_1: \alpha_i \neq 0$ for at least one α_i.

The Tea Null Hypotheses H_0 where $\beta_j = 0$ for all j and $H_1: \beta_j \neq 0$ for at least one β_j

The Interaction Null Hypotheses H_0 where $\gamma_{ij} = 0$ for all i, j and $H_1: \gamma_{ij} \neq 0$ for at least one γ_{ij}.
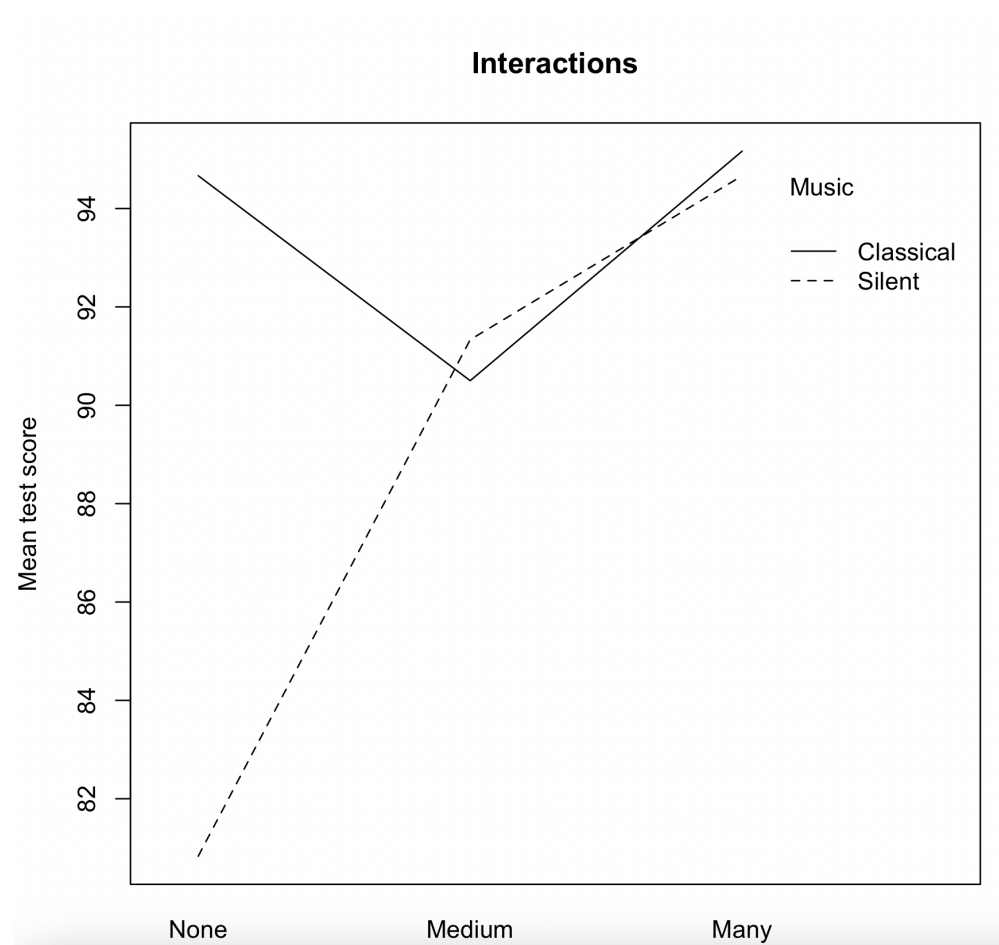
Results:

Interactions

Figure 1: Interaction plot by cups showing the mean test score per group
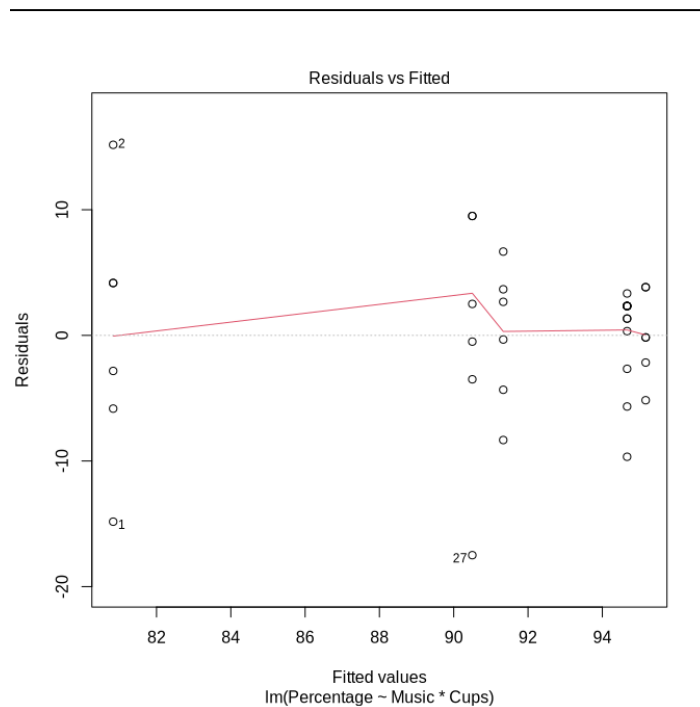
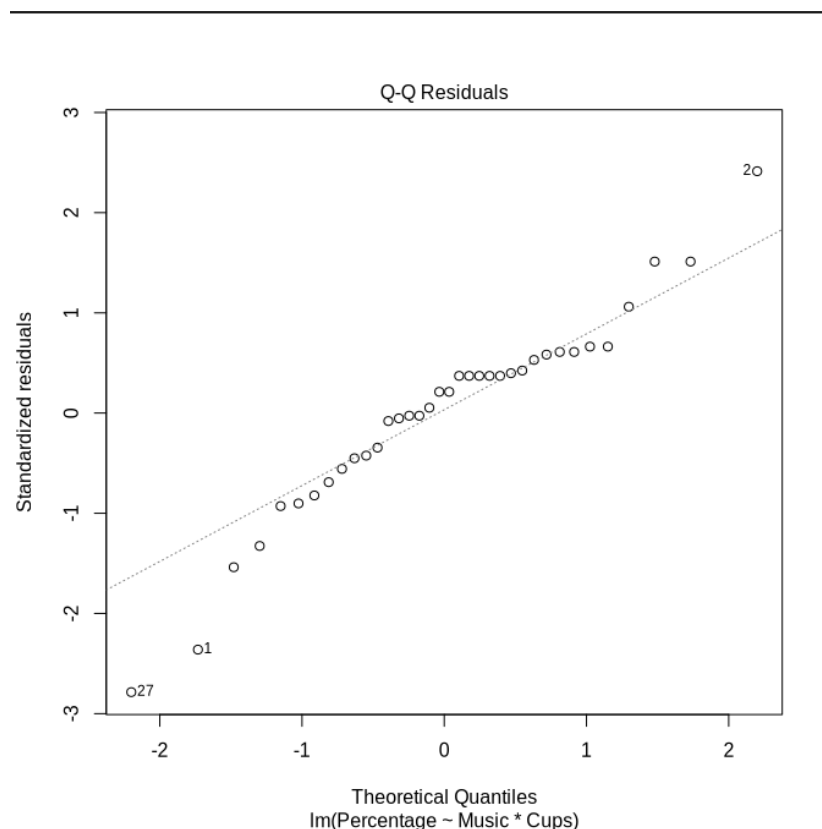Figure 2: Residuals versus fitted with outliers numbered

Figure 3: Q-Q plot of standardized residuals of test score against theoretical quantiles for all samples

The interaction plot heavily implies an interaction as the lines are non-parallel, with noticeable results only when going from no cognitive enhancers to any other level.

After completing the two-way ANOVA, it was found the principal (or main) effect of cups of tea and classical music versus silence had only a weak effect on test score (p-value = 0.059 and 0.052 respectively) but a strong interaction effect (p-value = 0.025), allowing us to reject the interaction null hypothesis. The two-way ANOVA had an overall R^2 of 0.38 indicating the model weakly explains the data.

The ANOVA subregions were then considered. To reduce the type-I error rate, a Bonferroni correction for the five possible ANOVA subsets was applied, shown in table 1

	P-Value
Music = Silent	0.065
Music = Classical	1
Cups = None	0.054
Cups = Medium	1
Cups = Many	1

Table 1: Results of one-way ANOVA Bonferroni corrected tests

Note that all 5 tests were considered as neither factor was deemed more important to check. From Table 1, only drinking tea when not listening to music, or listening to music when not drinking tea had a weakly significant effect on test score.

Concerning the modelling assumptions, the residuals (Figure 2) were symmetrical about the x-axis, implying the residual error mean is suitably close to zero. However, they were not equally spread with the variance seemingly decreasing as the score increased, implying the assumption that each group had an equal variance was not met which means the model would not be reasonable; but with the small sample size it was deemed approximately met so conclusions were still drawn.

Independence was met by the study design as the students were chosen randomly and assigned randomly to groups.

From the Q-Q plot (Figure 3), the data was roughly normal as they mostly fell on the line with nearly equal points above and below with slight skew towards the ends. The differences from normality were accepted due to the small sample size.

Discussion and conclusion

From this experiment, using a cognitive enhancer by itself had statistically weak correlations with test score increases. Combining tea and classical music together has

a strong interaction effect (p = 0.025). This implies the effects of tea consumption does differ when used with or without classical music, with the weak individual effects implying tea or classical music by themselves is may be impactful but not additive when combined.

Limitations of this study mainly revolve around the high results achieved by most of the students caused by the low difficulty of the test, with low scoring outliers massively increasing variance and divergence from normality. Future investigations should use harder tests and compare increases in results for students taking the test twice to reduce variability.

Bibliography:

Rizwan, A., Zinchenko, A., Özdem, C. *et al.* The effect of black tea on human cognitive performance in a cognitive test battery. *Clin Phytosci* 3, 13 (2017). https://doi.org/10.1186/s40816-017-0049-4

Wang, S. (2023). The effects of music on different cognitive performances. *Journal of Education, Humanities and Social Sciences, 8,* 717-723. https://doi.org/10.54097/ehss.v8i.4341.