

## **Mind over Music: The Effect of Music on Memory Game Performance**

### **Abstract**

This study evaluates the effect of music on memory game performance with data from The Islands, a virtual human population. Participants were subjected to 3 treatments – listening to no music, classical music, and heavy metal music – before being asked to complete a memory game. Performance was measured in the time that it took to complete the game. Analysis through Analysis of Variance (ANOVA) and Tukey's Honestly Significant Difference (HSD) test showed that listening to music was associated with longer game completion time. These findings suggest that music may impair cognitive performance.

## 1 Introduction

In today's world, listening to music has become commonplace, with subscription-based streaming services such as Spotify, YouTube Music, and Apple Music increasing access to music. A 2023 report by the International Federation of the Phonographic Industry (IFPI, 2023) shows that people spend more time listening to music than ever before, with an average time spent of 20.7 hours per week, up from 20.1 hours in 2022. People are also listening to a wide variety of music—the report identified more than 700 genres of music that people have explored.

Given the widespread consumption of music, numerous studies have been conducted on the implications of idle music consumption. A study by Cassidy and MacDonald (2007) investigated the performance of background music on cognitive task performance like immediate recall and free recall. Results showed that performance was poorer across all tasks with music compared with no noise. Other studies contextualized their findings in everyday activities: Crawford and Strapp (1994) found that the presence of music correlated with negative performance during studying, as well as Dibben and Williamson (2007) observed music was a possible form of distraction when driving.

Our team wanted to investigate if music has an impact on performance in short-term cognitive tasks. The choice of a memory game minimizes certain knowledge prerequisites, such as educational level or age, and allows for a clear metric to analyze: the length of time it takes the individual to complete the memory game. Based on prior studies, we expect that listening to music results in a longer completion time of the memory game across all age groups.

## 2 Methods

The data was collected from the Islands, a population of virtual human subjects, Islanders, who live in 27 villages across 3 islands. Participants were selected through random sampling. To account for variability within the short-term memory of different age groups, a complete randomized block design was used with age group as a block. Within each block, 3 different treatments were applied: control (listening to no music), listening to classical music, and listening to heavy metal music. The treatments were randomly assigned to participants within each block. After each treatment was applied, participants played a memory game that presented 30 cards and required participants to match pairs as quickly as possible. The time of completion was recorded in seconds for each participant. R was used to collect and analyze data throughout the study, with ANOVA and Tukey's HSD test to conduct primary analysis.

$$y_{ij} = \mu + \tau_i + \beta_j + \epsilon_{ij}$$

*Figure 1: Complete randomized block design statistical model*

A pilot study was conducted with 45 participants to determine the required sample size to obtain statistically significant results. The pilot study produced an estimated effect size of  $f^2 = 0.182$ . For a significance level of 0.05 and 80% power, it was determined that a sample size of 57 would be required.

## 3 Results and Interpretation

Results from the ANOVA test indicated that at a significance level of 0.05, while blocking by age was not significant, application of different treatments was significant ( $p$ -value = 0.0002). This

indicated that listening to different genres of music results in significant difference in performance on the memory game.

Further analysis was conducted with Tukey's HSD test to determine which and how specific treatments differed from one another. Control and classical music did not produce a significant difference in group means. However, when comparing control and classical music to heavy metal, significant differences in group means were observed. This showed that listening to heavy metal music significantly differs from listening to no music or classical music in results for time taken to complete the memory game, on average increasing the time by 17.6 (p-value = 0.0009) and 18.39 seconds (p-value = 0.0016) respectively.

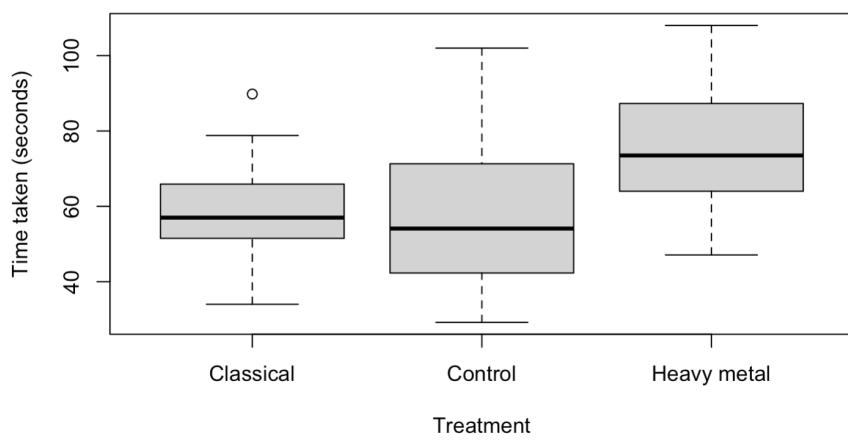


Figure 2: Boxplot showing memory game completion time by treatment

## 4 Discussion

Overall, music genre played a significant role in determining the participants' performance in the memory game. Listening to heavy metal results in longer time taken to complete the game, suggesting a hindrance in short-term memory recall.

The results from this study make sense in a real-world setting. Prabhu et al. (2022) found that students who completed memory tasks without listening to music scored higher than those who listened to music. This effect was apparent especially in genres like rock. Our finding that classical music had no significant effect compared to silence also matches the study, which suggests that instrumental or calming music may have little to a small positive impact on memory recall, depending on the type of memory recall being tested, as well as the individual.

A limitation of the study is the insignificant blocking factor, indicating that age did not significantly contribute to explaining the variation in the time taken to complete the memory game. Another limitation is inconsistent timing of administering the testing due to time constraints. It can create additional variation in participants' performance due to fluctuation of cognitive performance throughout the day. For example, a participant may be more alert during the afternoon rather than the evening, producing improved results regardless of the treatment administered.

Thus, future studies should utilize a significant blocking factor and consistent testing times across replicates and age groups to better control variability. A recommended next step would be to explore additional genres of music, such as country or rap, and music's longer-term effects on cognitive performance.

## References

- Cassidy, G., & MacDonald, R. A. R. (2007). The effect of background music and background noise on the task performance of introverts and extraverts. *Psychology of Music*, 35(3), 517–537. <https://doi.org/10.1177/0305735607076444>
- Crawford, H. J., & Strapp, C. M. (1994). Effects of vocal and instrumental music on visuospatial and verbal performance as moderated by studying preference and personality. *Personality and Individual Differences*, 16(2), 237–245. [https://doi.org/10.1016/0191-8869\(94\)90162-7](https://doi.org/10.1016/0191-8869(94)90162-7)
- IFPI. (2023, December 11). *IFPI's global study finds we're listening to more music in more ways than ever*. <https://www.ifpi.org/ifpis-global-study-finds-were-listening-to-more-music-in-more-ways-than-ever/>
- Prabhu, P., Nair, R., Lau, L., Chong, J., Sia, Z., & Aithal, P. (2022). An experimental study on the effect of background music on memory recall among medical students. *Journal of Datta Meghe Institute of Medical Sciences University*, 17(4), 853–856.

## Appendix

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
factor(age)	4	1460	365.1	1.240	0.302268
factor(treatment)	2	5404	2702.1	9.178	0.000296 ***
Residuals	68	20020	294.4		

Supplemental figure 1:

Summary of blocked ANOVA table, indicating insignificant block but significant treatment

Tukey multiple comparisons of means  
95% family-wise confidence level

```
Fit: aov(formula = time ~ factor(age) + treatment)

$treatment
  diff      lwr      upr      p adj
1-0  0.788 -10.840419 12.41642 0.9855736
2-0 18.388   6.759581 30.01642 0.0009324
2-1 17.600   5.971581 29.22842 0.0015775
```

Supplemental figure 2:

Summary of Tukey's HSD results, indicating a significant difference in group means for heavy metal compared to other treatments