The Effect of Music on Puzzle Cube Solving

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1 Abstract

Using a split-plot experimental design, this study examined the impact of three different music genres—classical, heavy metal, and no music—on cognitive function, specifically in the completion of a puzzle cube. A statistical simulation called The Island was used to carry out the experiment. The genre of music was the within-subject component; the presentation order of the various music genres, with gender blocking, was the between-subject factor. Thirty-six individuals, split into three treatment groups, finished the puzzles in each musical setting. The investigation, which used repeated measures ANOVA, showed that the order and genre of the music had a substantial impact on performance. When it came to completing puzzles, classical music outperformed no music and especially heavy metal, which was linked to the slowest times. The order in which the music was presented also had a major effect on performance, indicating effects related to learning or weariness. Gender disparities became significant, suggesting that men and women may react differently to different musical genres. Sequence and music genre interacted significantly, demonstrating the nuanced effects of these variables on cognitive function. These results imply that the kind of music and the sequence in which it is presented might influence cognitive tasks; heavy metal music is generally bad for you, whereas classical music is good.

2 Introduction

Numerous studies have examined how auditory stimuli affect cognitive function, with varying degrees of success on different cognitive tasks. Depending on the activity and the type of music, research has shown that music can affect cognitive function in both positive and negative ways. This study aims to explore how different musical genres affect a person's capacity to solve a puzzle cube, which requires fine motor skills, spatial reasoning, and problem-solving skills.

It takes a number of mental skills, such as imaging, sequencing, and spatial manipulation, to solve a puzzle cube. It's unclear how important ambient factors such as background music are in facilitating or obstructing these processes. While a number of studies show that certain musical genres, like classical music, might enhance cognitive function by lowering stress and generating the appropriate arousal state, other research claims other musical genres, such heavy metal, lead to cognitive overload and subpar performance.

In this work, we employed a split plot experimental design to comprehensively explore the effect of three different music conditions—classical music, heavy metal music, and no music—on puzzle cube solving efficiency. The split plot design is appropriate for this study because it allows for the assessment of both the primary effects of music genres and the interaction effects of music and individual participant variables, such as prior puzzle solving

experience and personal music preferences.

The major purpose of this study is to determine whether the type of music playing in the background influences the time required to solve a puzzle cube. By identifying the music conditions that either support or impede cognitive performance, this study hopes to provide insights into how auditory stimuli might be tuned to improve cognitive activities, which could have practical consequences for educational settings, workplaces, and other locations.

3 Methods

3.1 Participants

The participants will be islanders, randomly selected from a complete list of the whole population. The list was compiled by randomly choosing islands, cities, and houses. From this list, each islander will be assigned to one of three groups, each with a different sequence of music genres.

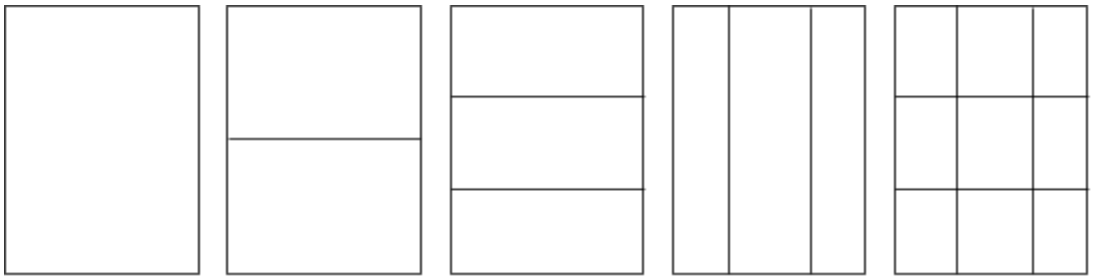
Each subject will participate in a repeated measures study where they listen to three different genres of music (control, classical, heavy metal) in a specific sequence assigned to their group. The subjects will listen to 10 minutes of one type of music and immediately after, they will solve a puzzle cube. This process will be repeated for the remaining two music genres in their specific sequence.

3.2 Design

The study will be set up as a Split Plot Design. The parameters for the designed are detailed below:

Response Variable	Time taken to solve puzzle cube		
Within-subjects Factor (Music Genre)	I. Control	II. Classical	III. Heavy Metal
Between-subjects Factor 1 (Sequence)	A. I →II→III	B. II →III→I	C. III →I→II
Blocking (Gender)	Male	Female	

The factor diagram is detailed below:



The primary objective of this study is to investigate the effect of different music genres (pop, rock, and control) on puzzle-solving time. To achieve this, we will control for potential gender differences by using gender as a blocking factor. This approach allows us to minimize the variability caused by gender, thereby focusing our analysis on the main effects of the music genres and the sequence in which they are presented. By employing split plot design, we aim to determine whether the genre of music influences cognitive performance in solving puzzles, while ensuring that gender differences do not confound the results.

3.3 Instruments

In this experiment, the effect of different music genres on puzzle cube solving performance will be measured. The participants will solve a standard Puzzle Cube under different music conditions. The chosen method ensures consistent and reliable data collection. Participants will be recruited from a pool of participants aged 18-24. Prior experience with solving puzzle cubes will be recorded, but both novices and experienced solvers will be included to increase the generalizability of the results. Each participant will provide informed consent before the experiment begins.

3.4 Procedure

Step 1: Find subjects from the Island willing to be a part of our experiment. After this,

Step 2: Randomly assign these groups (already divided by block) into different treatment groups for studying.

The different groups are:

A) Control, Classical, Heavy Metal
B) Classical, Heavy Metal, Control
C) Heavy Metal, Control, Classical

Step 5: For each unit, apply the assigned treatments to the islanders by having them listen to Classical music, Heavy Metal Music, or nothing (control).

Step 6: For each unit, measure their puzzle cube solve time after each treatment.

4 Data Analysis

4.1 Type of Statistical Analysis

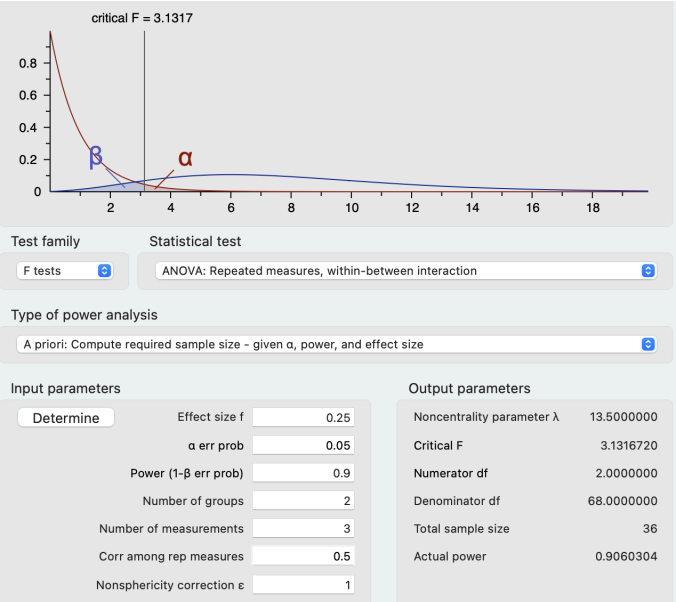
To analyze our data from our split plot design, we will use R to perform Mixed-Design ANOVA, also known as repeated measures ANOVA with between-subject factors, to examine the following:

- Within-Subject Factor: Music genre with three levels (classical, heavy metal, no music).
- Between-Subject Factor: Sequence of music types with three possible sequences (e.g., classical-heavy metal-no music, heavy metal-no music-classical).
- Blocking Factor: Gender with two levels (male, female).

The F-tests from the repeated measures ANOVA will tell us if there are significant differences in puzzle cube solving times across the different levels of music genre (classical, heavy metal, no music), if the sequence in which the music types are presented has a significant effect on puzzle cube solving times, and if there is a significant difference in puzzle cube solving times between genders. Additionally, it will also tell us whether there are any interaction effects between the factors.

4.2 Sample Size Determination

To determine the required sample size, G*Power uses the specified input parameters to calculate the power of the test for different sample sizes. The goal is to find the minimum sample size that achieves the desired power level—the likelihood of correctly rejecting the null hypothesis—while maintaining the specified effect size (0.25) and significance level (0.05). The calculation results in a total sample size of 36 participants (12 per treatment group), which is necessary to achieve the desired power of 0.9 for detecting the specified effect size with the given parameters. This sample size ensures the study is adequately powered to detect meaningful differences while controlling for Type I and Type II errors.



5 Results

5.1 ANOVA Analysis

	df	SS	MS	F-value	Pr(>F)
Genre	2	40.8	20.41	5.571	0.00588 **
Sequence	2	106.9	53.46	14.591	0.000006 ***
Gender	1	10.2	10.21	2.786	0.09999 .
Subject	32	1943.4	60.73	16.577	< 2e-16 ***
Genre:Sequence	4	45.1	11.26	3.074	0.02222 *
Genre:Gender	2	1.4	0.7	0.192	0.82597
Residuals	64	234.5	3.66		

Table 1: ANOVA table. The ANOVA results indicate that music genres with a p-value of 0.00588 and music sequence significantly affect puzzle-solving time. A significant interaction between music genre and sequence with a p-value of 0.02222 suggests that the sequence modifies the effect of the genre. Gender does not have a significant effect nor does it interact with music genres since both are not statistically significant. Blocking for gender helps reduce variability due to gender differences, allowing the significant effects of music genre and music sequence to be more clearly observed. These findings emphasize the impact of both music genre

and sequence on cognitive performance.

5.2 Tukey HSD Adjust P-values

	diff	lwr	upr	p adj
Control-Classical	0.250000	-0.83250599	1.332506	0.8447310
Heavy Metal - Classical	1.411111	0.32860512	2.493617	0.0073750
Heavy Metal - Control	1.161111	0.07860512	2.243617	0.0327464
B-A	0.3805556	-0.7019504	1.4630615	0.6775240
C-A	-1.8944444	-2.9769504	-0.8119385	0.0002466
C-B	-2.2750000	-3.3575060	-1.1924940	0.0000119
M-F	0.6148148	-0.1210779	1.350708	0.0999948

Table 2: Post-Hoc Analysis. Using Tukey's Honest Significance Difference, comparisons of differences in puzzle-solving times across different music genres and sequences were done. Heavy metal music significantly increases puzzle-solving time compared to both classical ($p = 0.0073750$) and control music ($p = 0.0327464$). There is no significant difference between control and classical music ($p = 0.8447310$). Regarding sequences, sequence C significantly reduces puzzle-solving time compared to both sequence A ($p = 0.0002466$) and sequence B ($p = 0.0000119$), with no significant difference between sequences B and A ($p = 0.6775240$). Additionally, the difference in puzzle-solving time between males and females is marginally significant ($p = 0.0999948$), suggesting a trend where males may have slightly longer solving times compared to females, although this does not reach the conventional level of statistical significance.

5.3 Residual Diagnostics

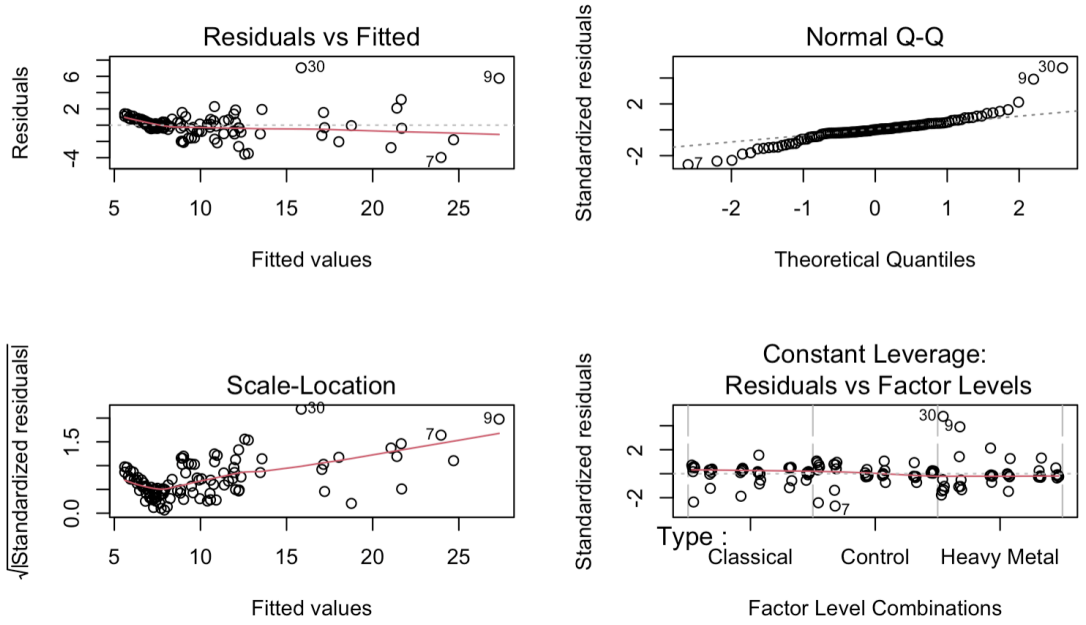


Figure 1: Summary Plots of Residuals for ANOVA Result. The diagnostic plots reveal that the linearity assumption is reasonably met, as indicated by the residuals vs. fitted values plot, though there is some increasing spread at higher fitted values suggesting potential heteroscedasticity. The normal Q-Q plot shows that the residuals are approximately normally distributed, with some deviations at the tails and notable outliers, particularly points 9 and 30. The scale-location plot further suggests heteroscedasticity, as the variance of residuals increases with fitted values. The residuals vs. factor levels plot indicates that residuals are fairly independent across different music genres, although some outliers are present. Overall, while the assumptions of linearity and normality are mostly satisfied, there are potential issues with heteroscedasticity and outliers that may require further investigation**.**

5.4 Interaction Plots

Figure 2: Interaction Plot of Music Genre and Sequence. The plot suggests that there is no interaction between sequence B and sequence C due to change in music genre. However, interaction is suggested within sequence A due to music genre.

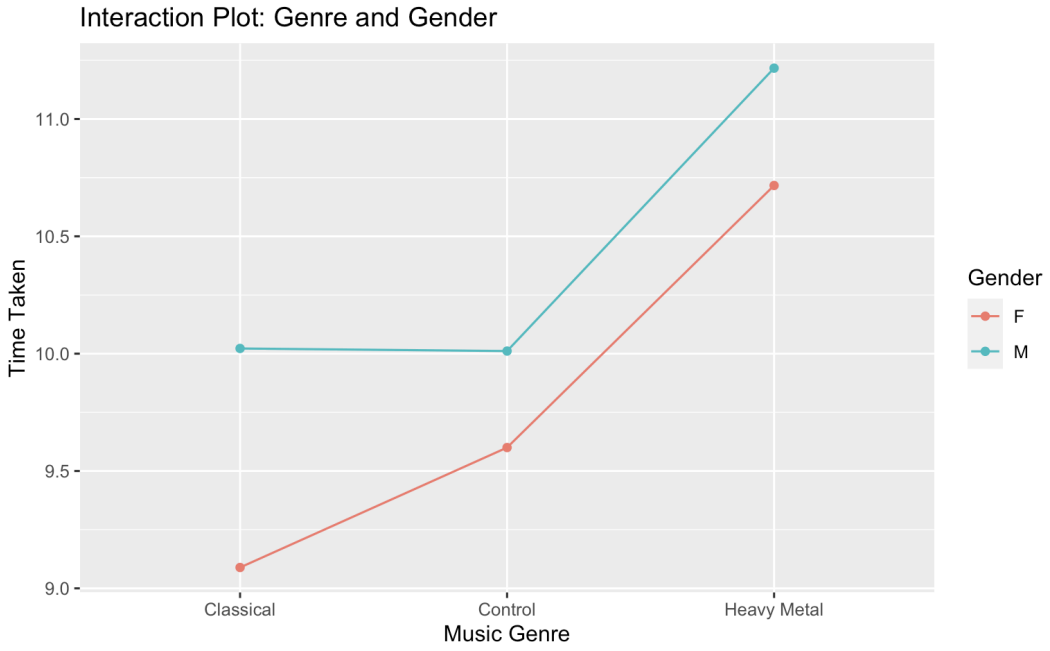


Figure 3: Interaction Plot of Music Genre and Gender. The plot suggests that there is no interaction between gender due to change in music genre.

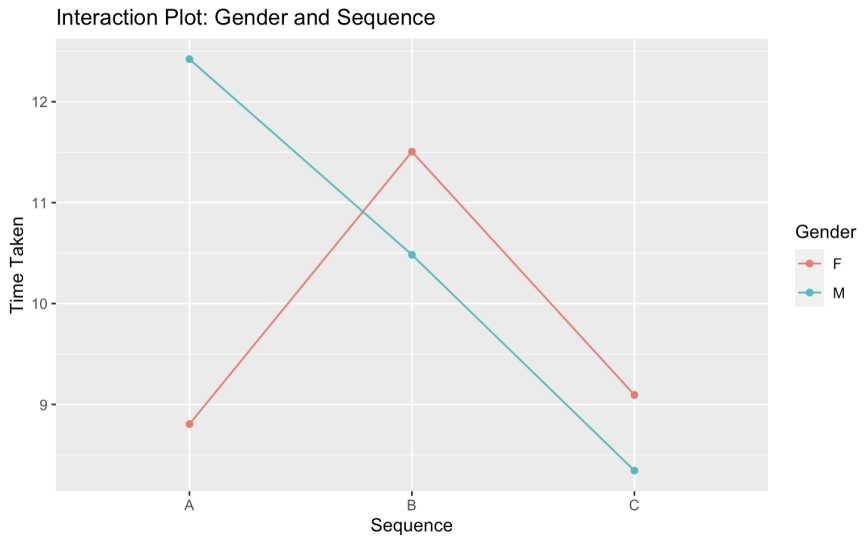


Figure 4: Interaction Plot of Sequence and Gender. The plot suggests that there is interaction between gender due to change in sequence.

5.5 Box Plots

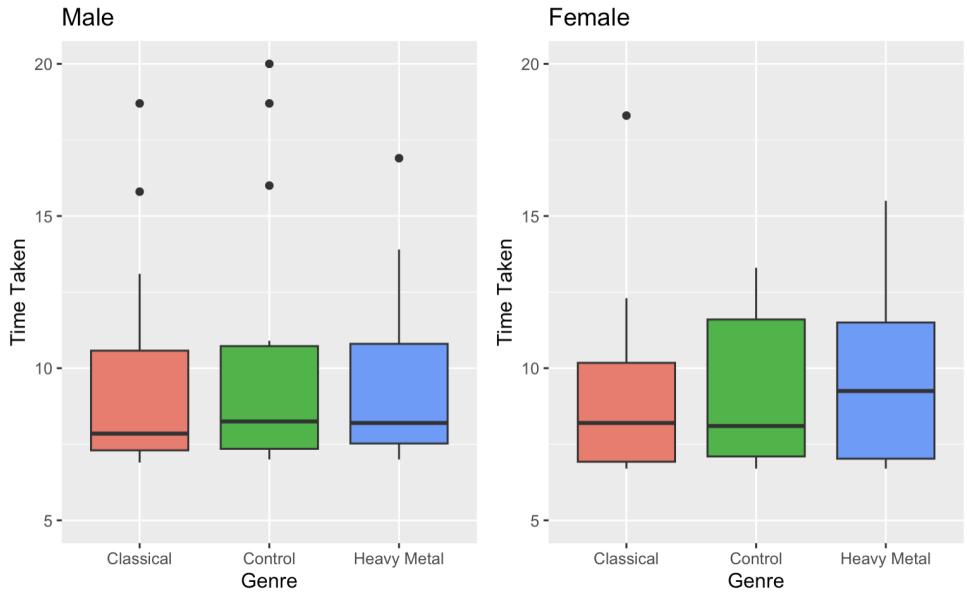


Figure 5: Side by Side Box Plot of Music Genres for Male and Female. For males, median puzzle-solving times are consistent across all music genres, with Heavy Metal showing more variability. For females, Classical music slightly improves and stabilizes performance, while Heavy Metal leads to more variability and outliers. Overall, Classical music benefits females, and Heavy Metal music introduces inconsistency for both genders.

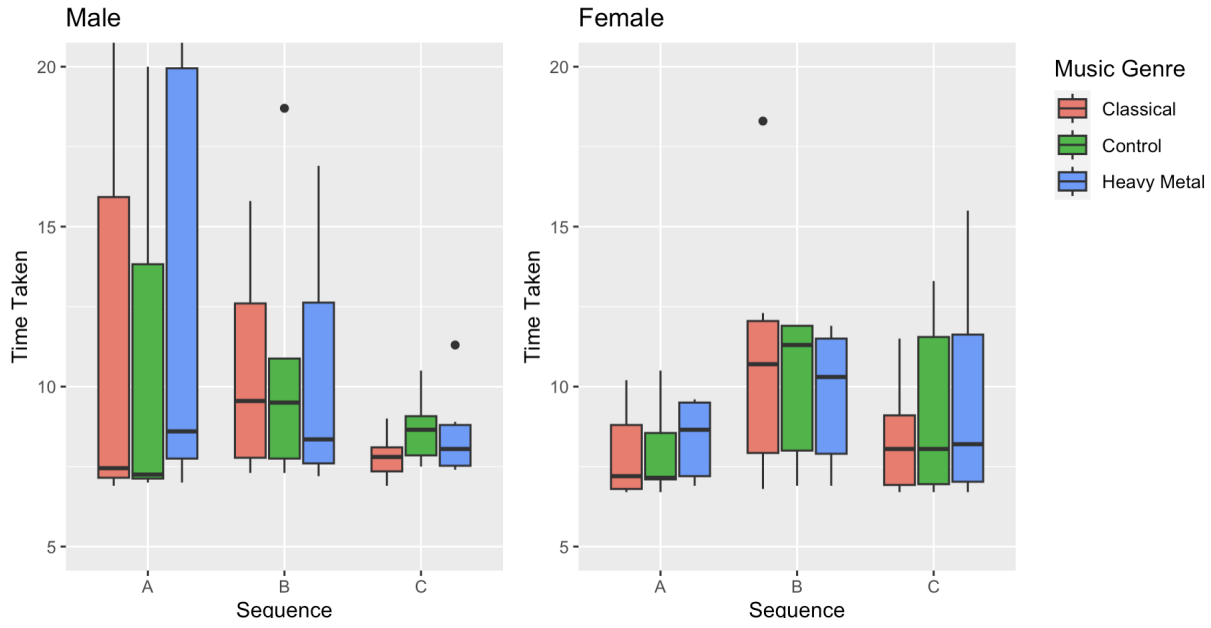


Figure 6: Side by Side BoxPlot of Sequence. The boxplots illustrate puzzle-solving times under different music genres (Classical, Control, Heavy Metal) for males and females across sequences (A, B, C). For males, sequence A shows high variability and longer times with Classical and Heavy Metal, while sequence B reduces times with Control performing best. Sequence C has lower variability across genres. For females, performance is consistent across sequences, with a slight increase in variability and times for Heavy Metal in sequence C. Males exhibit more variability, especially with Classical and Heavy Metal, while females are more consistent.

6 Discussion

The primary objective of this study was to investigate the effect of different types of music (classical, heavy metal, and no music) on cognitive ability, specifically in solving a puzzle cube, while accounting for potential gender differences. The experimental design used was a split-plot design, with music genre as the within-subject factor and sequence of music types and gender as the between-subject factors. The use of a repeated measures ANOVA allowed us to analyze the interaction between these factors and the cognitive performance of participants.

The analysis revealed significant effects of music genre, sequence of music types, and their interaction on puzzle-solving performance. Classical music significantly enhanced cognitive performance compared to no music (control) and heavy metal music, which was associated with the slowest (longest) puzzle-solving times. The sequence in which the music types were presented also had a significant impact, suggesting learning or fatigue effects. Although gender differences were not statistically significant at the 0.05 level, they approached significance. This indicates potential differences in how males and females respond to different

music genres. To add, the interaction between music genre and sequence was significant while the interaction between music genre and gender was not. These findings suggest that both the type of music and the order in which it is experienced can influence cognitive performance, with classical music generally being beneficial and heavy metal music being detrimental.

The study's findings add to the existing body of knowledge of how music impacts function, supporting the idea that classical music can improve performance, commonly known as the "Mozart effect." It also points out the effects of metal music on cognitive tasks. These results have implications for settings where cognitive performance is crucial, suggesting that playing music in classrooms and workplaces could potentially enhance cognitive functioning and productivity. Students might find it beneficial to listen to music while studying, for instance. Conversely, environments requiring focus may benefit from avoiding metal music.

There are limitations in this study that should be considered in research. Firstly, although the sample size was adequately powered, it was relatively small. Increasing sample sizes would enhance the applicability of the results. Secondly, the study only looked at three types of music conditions. Future studies could explore a wider range of music genres or incorporate different auditory stimuli like varied tempos and volumes. Lastly, while the puzzle cube task is a measure of ability, it may not capture all aspects of cognitive function. Future research could include a range of tasks to gain a more comprehensive understanding of how music affects cognition. Additionally, future research could explore the underlying mechanisms that account for the observed effects. For example, neuroimaging studies could investigate how different types of music influence brain activity related to cognitive processing. Moreover, examining individual differences in music preference and prior musical training could provide further insights into the moderating factors that influence the relationship between music and cognitive performance.

This study illustrates the impact that music genre can have on cognitive performance, with classical music enhancing and heavy metal music impairing puzzle-solving abilities. The findings also highlight the influence of the sequence of music types on cognitive performance, while gender differences in response to music approached significance. These insights contribute to the broader understanding of the cognitive effects of music and offer practical recommendations for optimizing environments to enhance cognitive performance. Future research should continue to explore this dynamic relationship, addressing the limitations and expanding the scope of investigation to further our understanding of how music influences the mind.

7 References

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