The Modulatory Effects of Music Genre and Exposure Duration on Cognitive Focus

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1. Abstract

Music is widely used as a cognitive enhancer in fast-paced environments, particularly among students and working professionals. This study examines the effects of musical genre (classical, country, dance, heavy metal) and listening duration (10, 20, 30 minutes) on attention. A two-factor ANOVA, with sex and age as blocking variables, was used to evaluate changes in performance on a sustained attention task before and after music exposure. Results revealed significant main effects and interactions: classical, country, and dance music resulted in no significant change from baseline performance, whereas heavy metal impaired it. Longer exposure (30 minutes) was found to be more detrimental to attention than shorter exposure (10 minutes). These findings offer practical insights for incorporating music into productivity-enhancing settings.

2. Introduction

The impact of background music on cognitive focus has garnered increasing interest, particularly in academic and professional contexts where individuals often rely on music to sustain attention. Although previous research has shown that music can influence attentional performance, findings remain mixed. Music's effect is not uniform but is instead a complex interaction between its structural properties, the demands of the cognitive task, and individual listener differences (Cheah et al., 2022).

Two primary theories attempt to explain these varied effects. The Arousal-Mood Hypothesis posits that music alters cognitive performance by modulating the listener's physiological arousal and emotional state, with pleasant and moderately arousing music often enhancing performance (Schellenberg, 2012). Conversely, Cognitive Load Theory suggests that music, especially with lyrics or high complexity, can consume limited working memory resources, creating an extraneous load that interferes with the primary task (Howley-Rouse, 2024).

Genre-specific effects are often interpreted through these theoretical lenses. Classical music gained notoriety with the "Mozart Effect," where Rauscher et al. (1994) initially reported that listening to Mozart temporarily enhanced spatial-temporal reasoning. However, subsequent research has largely reinterpreted this phenomenon, attributing it more to enjoyment and increased arousal rather than an intrinsic quality of the compositions (Schellenberg, 2012). In contrast, high-intensity genres like heavy metal are frequently found to impair concentration due to over-arousal or high informational load (Cassidy & Macdonald, 2007; Lin et al., 2023). While research on dance music is emerging, with theories suggesting its stimulating qualities may enhance motivation, empirical data on specific attention tasks remains sparse (Kallista et al., 2024). Notably, the cognitive effects of country music represent a significant gap in the literature.

Alongside genre, listening duration is another critical modulating factor, as effects can change over time due to habituation (Banbury & Berry, 1997), with both brief and extended

listening yielding different cognitive outcomes. However, despite these insights, relatively few studies have examined how genre and duration interact within a single experimental framework.

The present study addresses this gap by investigating how different combinations of music genre (classical, country, dance, and heavy metal) and listening duration (10, 20, and 30 minutes) affect attention, as measured by performance on a sustained attention task. To control for individual variability from factors like age and personality (Bottiroli et al., 2014; Cassidy & Macdonald, 2007), a two-factor ANOVA with blocking for age group and sex is employed. This research aims to build on and clarify existing findings by systematically investigating under-explored genres and their interaction with exposure time, contributing to a more cohesive understanding of music-induced cognitive modulation.

3. Methods

3.1. Participants

Participants were residents of Ironbard Island, selected through a multistage random sampling process designed to ensure demographic balance. First, the town of Hofn was randomly selected. Then, households within Hofn were randomly chosen from a numbered list. From each household, if it was occupied, one individual was randomly selected using stratified criteria based on age group and sex. This approach ensured balanced representation across all combinations of experimental conditions and blocking factors. The final sample consisted of 216 participants, evenly distributed across all groups.

3.2. Design

We employed a two-factor ANOVA design with blocking to control for potential confounding variables related to age and sex.

Response Variable	Change in Number of Misses			
Treatment 1 (Type of Music)	Classical	Country	Dance	Heavy Metal
Treatment 2 (Listening Duration)	10 minutes	20 minutes	30 minutes	
Blocking 1 (Age Group)	18–30	31–44	45 and above	
Blocking 2 (Sex)	Male	Female		

Table 1. Experimental Design Factors and Levels.

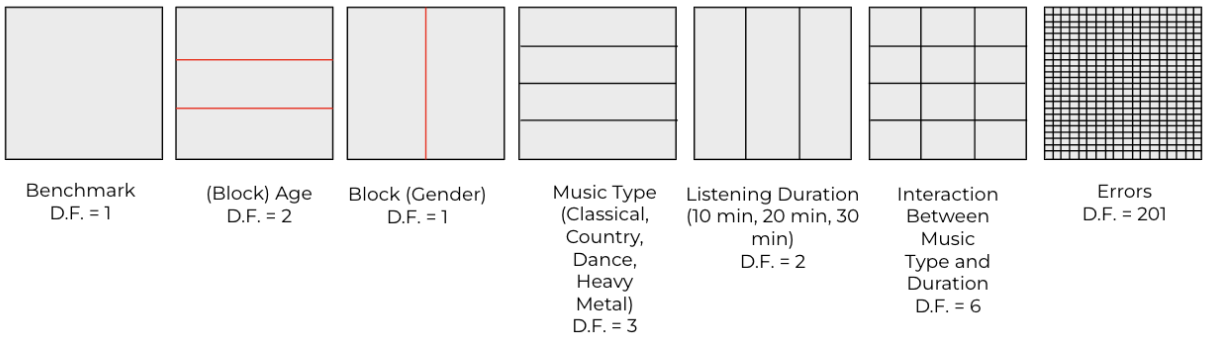

Figure 1. Degrees of Freedom for the ANOVA Model.

The two independent variables were music genre and listening duration, selected based on prior research suggesting their influence on attentional processes and cognitive performance. Our primary aim was to investigate whether either factor affects performance on an attention test, and whether there is an interaction between them.

Blocking was applied using age and sex, as prior studies indicate that attentional responses to music may vary across age groups and between sexes. This design allows us to isolate the effects of music genre and duration while accounting for these known demographic influences.

3.3. Instruments

An attention task was used to assess cognitive focus. The task, administered both before and after music exposure, recorded the number of misses on a visual test. The musical selections represented four genres (classical, country, dance, and heavy metal) and were presented in three durations of 10, 20, or 30 minutes.

3.4. Procedure

1. **Recruitment:** The recruitment process began with a numbered list of all households in the pre-selected town of Hofn. A random number generator was then used to select the target number of households. At each selected household, if it was occupied, a single participant was recruited using stratified criteria based on age and sex to ensure balanced representation in the blocking scheme. Informed consent was obtained from each individual before participation.
2. **Assignment to Conditions:** Following recruitment and blocking, each participant was randomly assigned to one of 12 experimental conditions, each representing a unique combination of music genre (classical, country, dance, or heavy metal) and exposure duration (10, 20, or 30 minutes).
3. **Baseline Testing:** Before any music exposure, each participant completed an attention test to establish a baseline score. The number of missed responses during this test was recorded.

4. **Music Exposure:** Participants then listened to the music track corresponding to their assigned experimental condition for the specified duration.
5. **Post-Exposure Testing:** Immediately after the music session, participants completed the same attention test a second time. The number of missed responses was recorded again.
6. **Data Calculation:** The primary variable for analysis was the "change in the number of missed responses." This was calculated for each participant by subtracting their baseline (pre-music) number of misses from their post-music number of misses.

4. Data Analysis

4.1. Type of Statistical Analysis

The data were analyzed using a two-factor Analysis of Variance (ANOVA) to assess the main effects of music genre and listening duration, as well as their interaction effect, on attentional performance. Age group and sex were included as blocking variables to control for potential demographic influences. The dependent variable was the change in the number of misses on an attention test (post-exposure score minus pre-exposure score). The model's assumptions of normality, homoscedasticity, and linearity were verified using residual diagnostics. Significant effects were subsequently explored with Tukey’s Honest Significant Difference (HSD) post-hoc test for pairwise comparisons.

4.2. Sample Size Determination

Sample size was determined using G*Power software, assuming an effect size of 0.3, a significance level (α) of 0.05, and statistical power of 0.80. The minimum required sample size was calculated to be 159 participants. To ensure adequate representation across all treatment groups and blocking factors, a total of 216 participants were recruited.

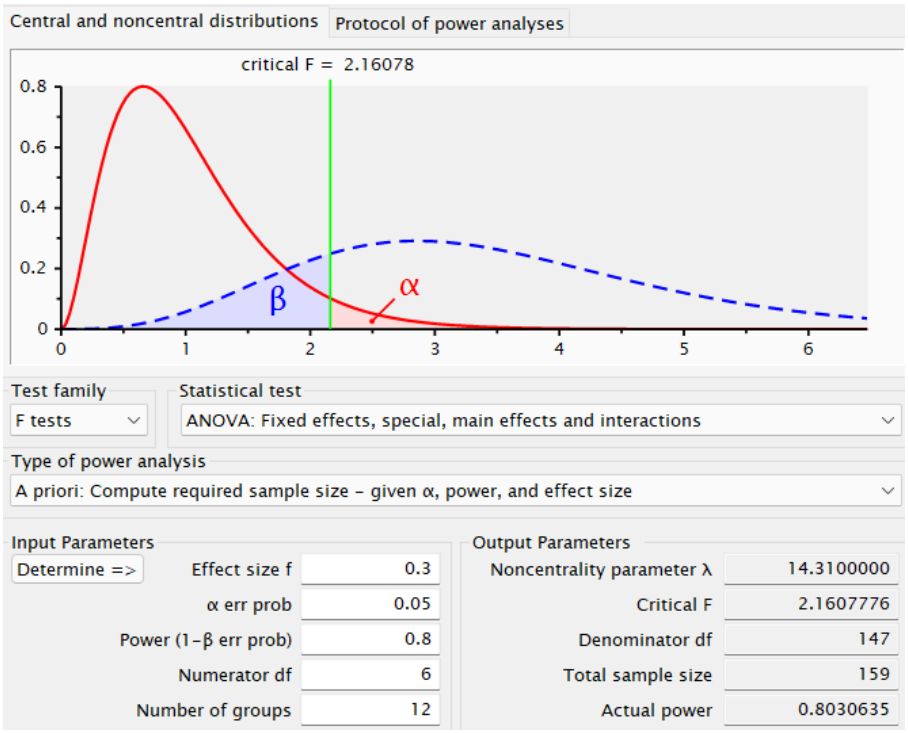

Figure 2. A Priori Power Analysis for Sample Size Determination.

5. Results

5.1. ANOVA Analysis

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Music Type	3	23141.31	7713.77	137.28	< .001
Listening Duration	2	495.73	247.87	4.41	0.013
Age Group	2	93.79	46.89	0.83	0.436
Gender	1	138.56	138.56	2.47	0.118
Music Type * Listening Duration	6	980.56	163.43	2.91	0.01
Residuals	201	11294.60	56.19	NA	NA

Table 2. Results of the Two-Factor ANOVA with Blocking.

The ANOVA results revealed significant main effects of Music Type ($F = 137.28$, $p < 0.001$) and Listening Duration ($F = 4.41$, $p = 0.013$), as well as a significant interaction between Music Type and Listening Duration ($F = 2.91$, $p = 0.010$) on the change in the number of missed responses. In contrast, the blocking factors age group ($F = 0.83$, $p = 0.436$) and sex ($F = 2.47$, $p = 0.118$) did not reach statistical significance at the 0.05 level. These results suggest that while music genre and listening time influence attentional performance, the inclusion of age group and sex as blocking factors may not enhance model efficiency and might be omitted in future analyses.

5.2. Residual Diagnostics

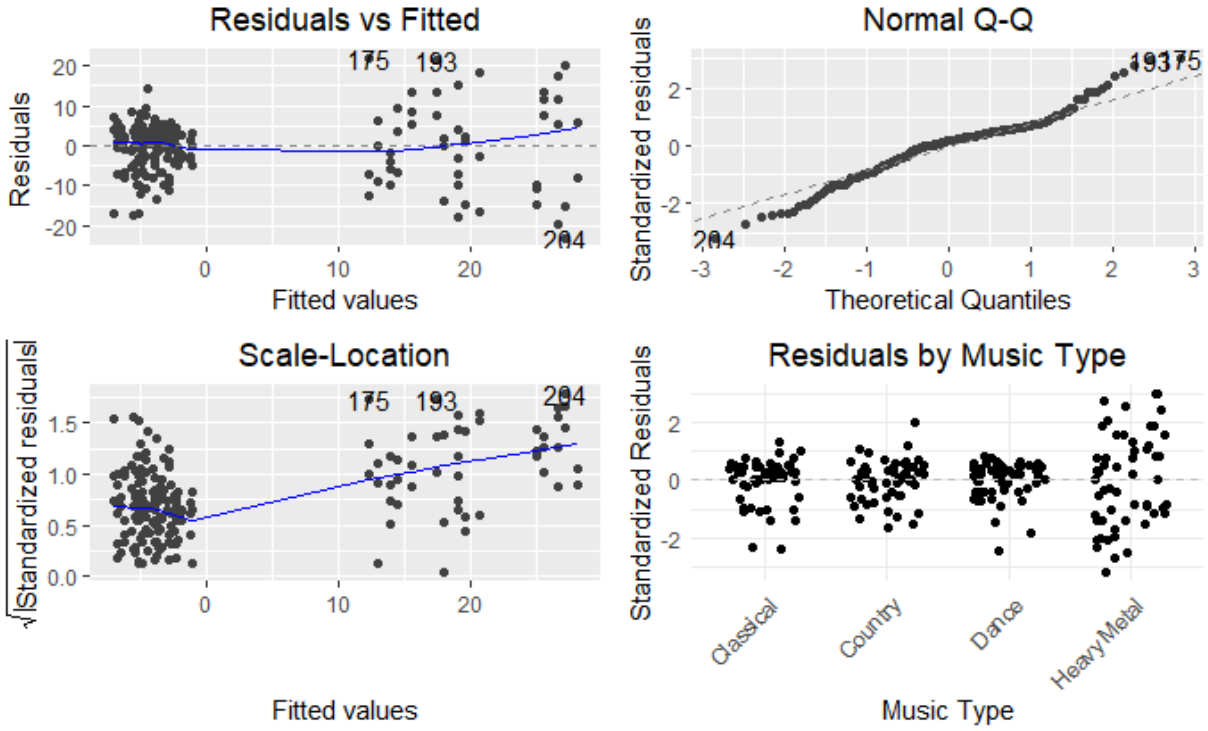

Figure 3. Diagnostic Plots for ANOVA Model Assumptions.

The Residuals vs. Fitted plot shows residuals generally clustered around zero, supporting the linearity assumption of the model. However, some data points, primarily from the Heavy Metal genre, deviate noticeably from this pattern, indicating potential localized nonlinearity. The Q-Q plot reveals slight deviations in the tails—specifically at the lower left and upper right—though overall, the normality assumption of the error terms is reasonably met.

The Scale-Location plot displays a largely random scatter, consistent with the assumption of homoscedasticity, although observations related to Heavy Metal again show greater deviation from the overall pattern. Residuals by Music Type indicate that most standardized residuals fall within the ±2 range, suggesting minimal influence of outliers, except for increased variability within the Heavy Metal group.

In summary, the model assumptions are generally satisfied, but certain observations linked to Heavy Metal music exhibit notable deviations in the Residuals vs. Fitted and Scale-Location plots.

5.3. Interaction Plots

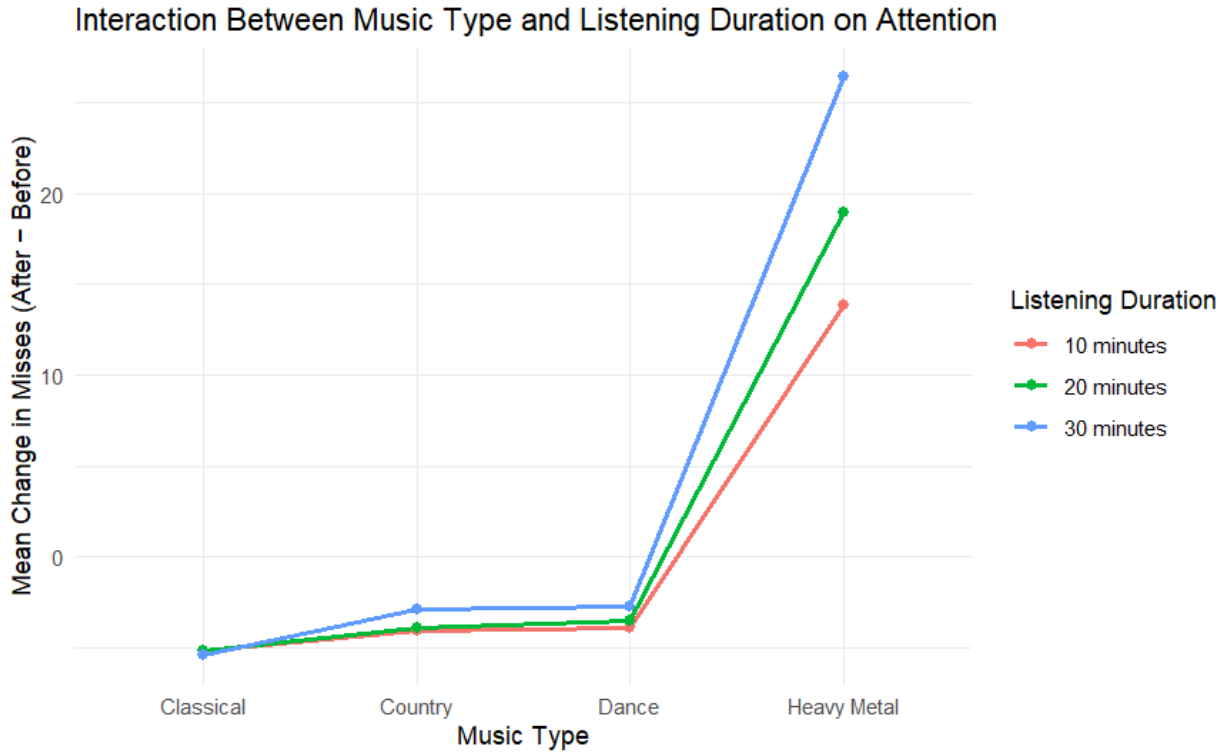

Figure 4. Interaction between Music Type and Listening Duration on Attention.

The interaction plot demonstrates a marked increase in missed responses among participants exposed to Heavy Metal music, with this negative effect becoming more pronounced as listening duration increases. In contrast, Classical, Country, and Dance music exhibit minimal to no change in the number of missed responses across all durations, indicating these genres do not adversely affect attentional performance. These findings suggest a specific and escalating detrimental impact of Heavy Metal on attention, particularly with prolonged exposure.

5.4. Box Plots

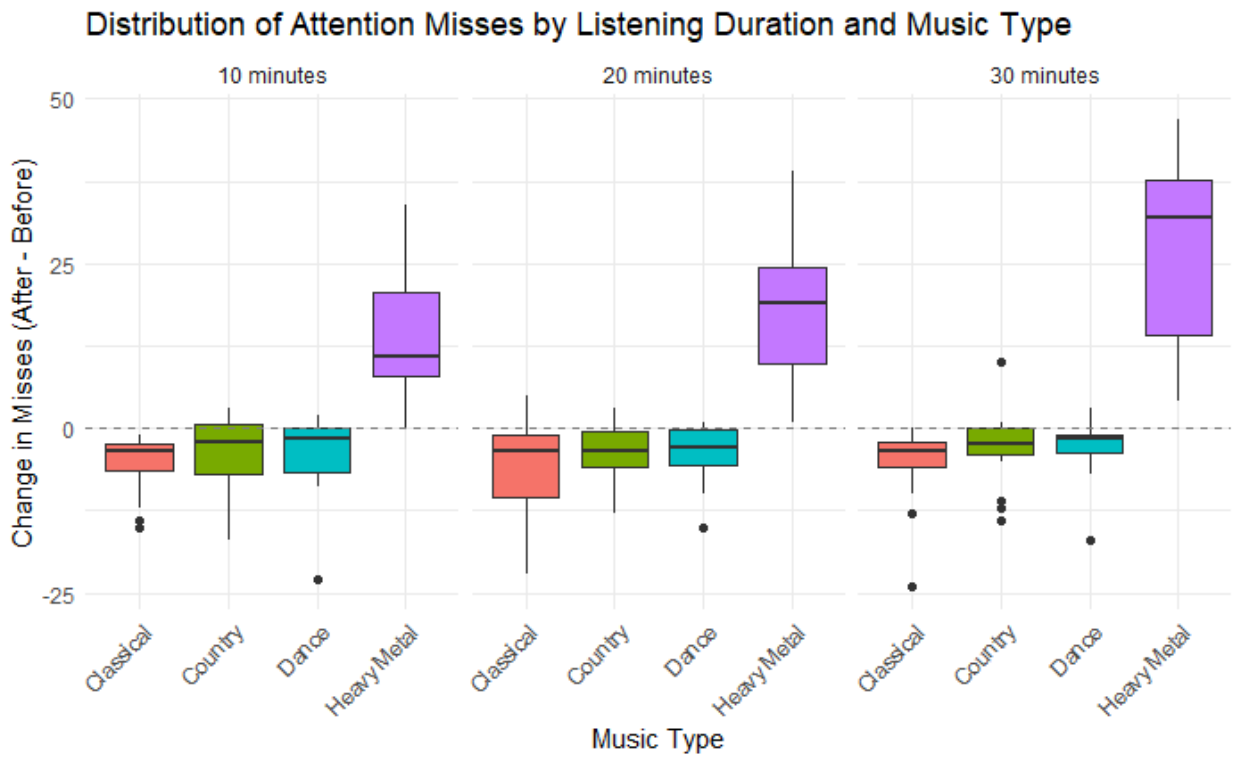

Figure 5. Distribution of Attention Misses by Music Type and Duration.

Across all listening durations (10, 20, and 30 minutes), Classical, Country, and Dance music generally resulted in stable or improved attention, as reflected by median values near or below zero and relatively narrow interquartile ranges. Conversely, Heavy Metal consistently showed a notable increase in missed responses, particularly with longer listening durations, indicating a detrimental effect on attention. This effect appears dose-dependent, with the most pronounced negative impact observed after 30 minutes of exposure to Heavy Metal music.

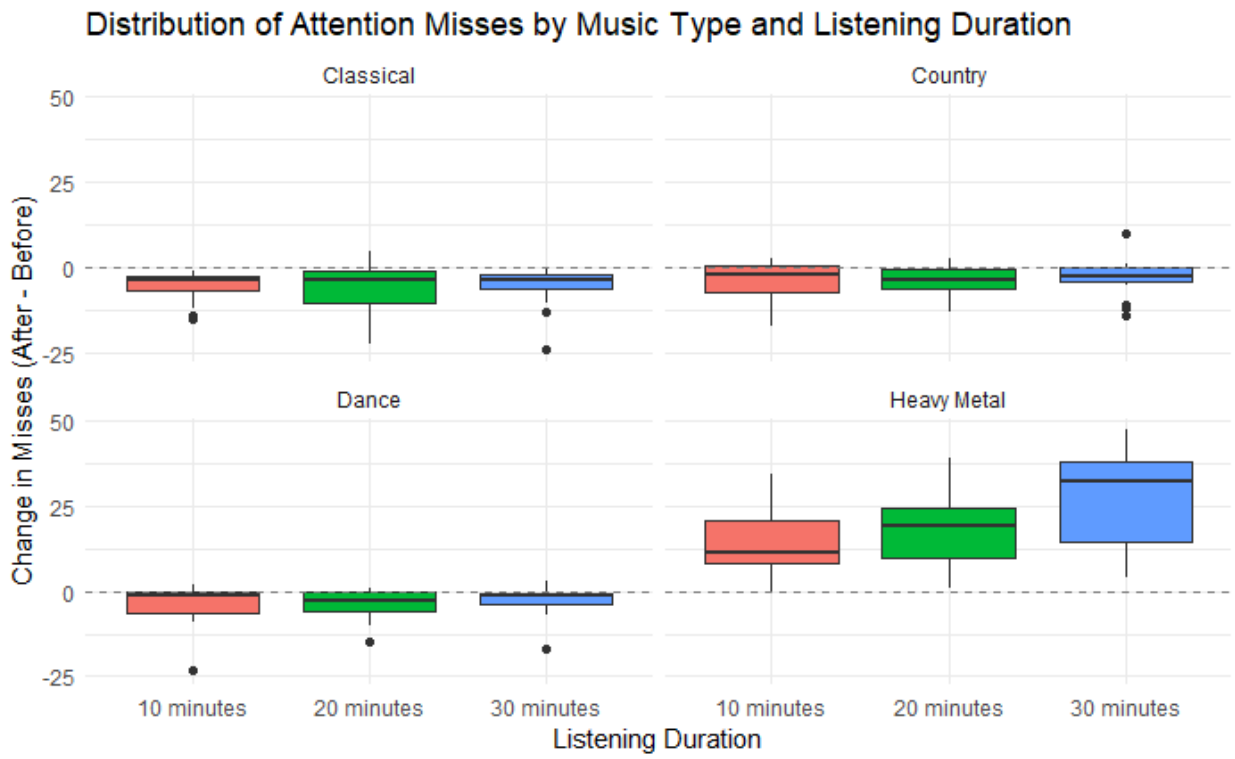

Figure 6. Distribution of Attention Misses by Duration and Music Type.

For Classical, Country, and Dance music, performance remained relatively stable across all listening durations (10, 20, and 30 minutes), with median changes in attention misses near zero or slightly negative. This suggests that listening duration did not substantially affect attention for these genres. In contrast, Heavy Metal exhibited a clear increase in attention misses as listening duration increased, with both median values and variability rising. These findings indicate that extended exposure to Heavy Metal music may impair focus.

5.5. Tukey HSD

	diff	Lower CI	Upper CI	p adj
Country-Classical	1.67	-2.07	5.40	0.656
Dance-Classical	1.85	-1.89	5.59	0.574
Heavy Metal-Classical	25.02	21.28	28.76	< .001
Dance-Country	0.19	-3.55	3.92	0.999
Heavy Metal-Country	23.35	19.61	27.09	< .001
Heavy Metal-Dance	23.17	19.43	26.90	< .001

Table 3. Tukey HSD Post-Hoc Comparisons for Music Type.

No statistically significant differences were found in the change in the number of missed responses between Classical, Country, and Dance music (all adjusted p-values > 0.5), indicating

these genres had similarly neutral effects on performance. In contrast, Heavy Metal music resulted in significantly worse performance, showing a greater increase in misses compared to all other genres: Classical (mean difference = 25.02, $p < 0.001$), Country (mean difference = 23.35, $p < 0.001$), and Dance (mean difference = 23.17, $p < 0.001$). These results highlight a pronounced and unique detrimental effect of Heavy Metal on sustained attention within this study.

	diff	Lower CI	Upper CI	p adj
20 minutes-10 minutes	1.43	-1.52	4.38	0.488
30 minutes-10 minutes	3.68	0.73	6.63	0.010
30 minutes-20 minutes	2.25	-0.70	5.20	0.172

Table 4. Tukey HSD Post-Hoc Comparisons for Listening Duration.

Listening for 30 minutes resulted in significantly poorer performance compared to listening for 10 minutes (mean difference = 3.68, $p = 0.010$). However, the differences between 20 minutes and 10 minutes ($p = 0.488$) and between 30 minutes and 20 minutes ($p = 0.172$) were not statistically significant.

6. Discussion

The objective of this study was to assess the combined influence of music genre and listening duration on sustained attention. Our findings clearly demonstrate that while some music genres severely impair cognitive focus, others were associated with stable performance. Utilizing a randomized complete block design with a statistically robust sample, our ANOVA results revealed significant main effects for both music genre and listening duration, as well as a significant interaction between them. The blocking variables of age group and sex, however, were not significant, suggesting the influence of music was robust enough in this context to be consistent across the demographic groups sampled. Nonetheless, it is important to note that this lack of a moderating effect may not generalize to all populations or cognitive tasks.

The nature of the interaction was explored through interaction plots, box plots, and Tukey HSD post-hoc tests. These analyses revealed a strong, specific effect involving Heavy Metal music, which consistently led to a significant increase in attention misses. This detrimental impact was dose-dependent, intensifying as listening time increased from 10 to 30 minutes. Conversely, Classical, Country, and Dance music were associated with stable performance across all durations. Notably, by demonstrating a neutral effect, the findings on Country music begin to fill a significant gap previously identified in the literature.

These findings offer a clearer understanding of the underlying cognitive mechanisms. The results are not fully explained by the Arousal-Mood Hypothesis, which might predict a performance boost from moderately arousing music like Dance music (Schellenberg, 2012). Instead, our findings align more strongly with Cognitive Load Theory. The high-arousal, lyrical complexity, and structural variability of Heavy Metal likely imposed an extraneous cognitive

load, consuming working memory resources needed for the primary attention task—a finding that supports previous research on high-intensity genres (Cassidy & Macdonald, 2007). The other genres, being less cognitively demanding, did not impose this load, thus allowing focus to be maintained.

While this study provides clear results, several limitations must be acknowledged, which also highlight important avenues for future research. First and foremost, the absence of a no-music control group means we can only infer that certain genres prevent attentional decline; we cannot definitively measure this against a natural change in performance over time in silence. Future research should include a no-music condition to establish this crucial baseline. Second, although age and sex were not significant moderators here, other individual differences—such as personality traits (e.g., introversion/extraversion), music preference, and prior musical training—could be powerful moderators that were not measured. Third, the sampling was confined to a single town (Hofn) on one island (Ironbard), which may limit the external validity of our findings. The populations of other islands, such as Providence and Bonne Santé, or even other towns on Ironbard, could possess distinct demographic, cultural, or environmental characteristics that influence their cognitive responses to music. Future research could employ a stratified sampling method across multiple islands to assess the potential moderating effects of regional culture or environment. Furthermore, our findings are specific to a sustained attention task; other cognitive domains, such as creative problem-solving or memory recall, may be affected differently. Finally, this study examined durations only up to 30 minutes. Future work should explore longer periods to determine if the detrimental effects of high-load music plateau or if the neutral effects of other genres eventually begin to wane.

In conclusion, this research indicates that the choice of background music is critical for preserving cognitive focus. The practical implication is that for tasks requiring sustained attention, the most effective strategy may be to select genres that prevent cognitive interference rather than to seek direct performance enhancement. By choosing music that does not overload cognitive resources, individuals can create an auditory environment that supports, rather than hinders, their ability to concentrate.

7. References

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