Business Experimentation and Causal Methods

Does listening to jazz music impact task performance, concentration, and perceived enjoyment?

Arnav Sachdeva, Aryan Sehgal, Nimisha Agarwal, Rashi Jaiswal, Shrinidhi Bhide (Group 14)

Introduction

Jazz music has a distinctive ability to engage the mind while seamlessly blending into the background, fostering an atmosphere of focus without becoming a distraction. Its improvisational essence infuses a continuous stream of creativity and variation, keeping listeners stimulated and inspired without overwhelming their senses. While some studies demonstrate positive effects of background music on cognitive tasks, others indicate that background music may disrupt cognitive performance in certain contexts. The effectiveness of piano jazz music appears to depend on individual differences, the specific cognitive task being performed, and the characteristics of the music itself.[1,2]

We are doing this experiment to investigate whether listening to piano jazz music has an impact on work output, mental engagement, and personal gratification.

Null hypothesis (H0): Listening to piano jazz music has no effect on task performance, stress levels, focus levels, and perceived enjoyment.

Alternative hypothesis (H1): Listening to piano jazz music has an effect on task performance, stress levels, focus levels, and perceived enjoyment.

Experiment Design

The data collection for this experiment was constructed to systematically collect essential demographic data, task performance metrics, and subjective experience measures from participants. The design included the following elements:

Participants

We approached 62 people, all of them from BU irrespective of the program they were enrolled in.

Intervention

Each group will complete a simple task (Numerical countdown, and sorting a well shuffled deck of cards). Participants were randomly assigned to one of two groups using a coin toss to ensure the impartiality of the treatment allocation.

- **Treatment Group (With Music)**: Participants in this group completed the tasks while listening to jazz piano music in common spaces like Libraries, Atrium, and Grad Lounge. The choice of jazz piano was based on its non-intrusive yet complex structure.
- **Control Group (No Music)**: Participants in this group performed the tasks in common spaces establishing a baseline for cognitive performance. This group helped to isolate the effect of music by providing a comparative standard against the treatment group.

Randomization Procedure

Each participant was assigned their group based on the outcome of a coin toss, heads for the treatment group and tails for the control group. This method was chosen for its simplicity and randomness, ensuring that each participant had an equal probability of being assigned to either group.

Pre-Experiment Variables

Demographic Data: Participants were required to provide their age, gender, and native language to identify any demographic variables that could influence the results.

Music and Work Environment Preferences: Questions assessed the importance of a quiet environment and the frequency of listening to music while working. These allowed us to understand individual differences in background noise preference and set a baseline perception.

Outcome Variables

Task Performance: The survey captured quantitative data on:

- **Time Taken for Task 1 - Countdown**: Participants performed continuous subtractions, with their completion times recorded. They began from 100 and subtracted 7 until they reached the last positive digit. This tested their numerical and computational skills.
- **Score for Task 1 - Countdown**: Accuracy of the computations was scored out of a possible 14 points.
- **Time Taken for Task 2 - Card Sorting**: Participants were asked to sort a shuffled pack of cards into their four categories. This task tested organizational and spatial skills.
- **Score for Task 2 - Card Sorting**: Effectiveness in card sorting was scored out of a possible 52 points.
- **Subjective Experience Measures**: Post-task questions on a Likert scale from 1 to 7, gauged participants' stress, enjoyment, and focus levels, providing insight into the psychological impact of the experimental conditions.

Pilot Study

We conducted a pilot study with six participants, which helped us identify key improvements for our data collection process. We realized the need for a standardized Google Form for data collectors use, to ensure consistency in collecting demographic and task-related responses. Additionally, we recognized the importance of providing uniform task instructions to all participants to minimize variability in task execution. The pilot study also highlighted that our initial focus was solely on accuracy scores, prompting us to introduce an additional task specifically designed to assess spatial and organizational skills more effectively.

Data Collection

Data for the experiment was collected entirely through in-person sessions conducted in a controlled environment as aforementioned. This approach allowed for meticulous standardization of experimental conditions, ensuring that all participants experienced consistent audio levels and task settings. Those in the treatment group completed the tasks with jazz piano music played through standardized headphones, while the control group performed under the same environmental conditions. This setup facilitated precise monitoring and recording of task performance metrics such as completion times and accuracy scores. Conducting the experiment in-person ensured that environmental variables were uniformly regulated across all participants, enhancing the integrity and reliability of the collected data.

Analysis

Data Cleaning

As part of our data preprocessing, we removed the Timestamp and Additional Comments columns, as they did not contribute to our analysis. We also cleaned the Language column by trimming extra spaces, ensuring proper capitalization, and correcting typos such as "Engish" to "English." Additionally, we simplified entries by removing instances of ', Hindi' and consolidating "English, Hindi" into "English" for consistency. To further streamline the dataset and improve regression results, we also renamed several columns to more concise and meaningful labels, making the data easier to interpret and analyze.

Analysis Procedure:

We performed a combination of statistical and exploratory techniques to assess the effects of background music on task performance and subjective experiences. Correlation analysis, including a correlation matrix, identified relationships between task performance, stress, enjoyment, and demographic factors. Boxplot analysis was used to compare age distributions between treatment and control groups. The study estimated Average Treatment Effects (ATE) and Conditional Average Treatment Effects (CATE) to examine overall and gender-specific impacts of music. Independent T-tests were conducted to determine the statistical significance of observed differences, while statistical power and effect size analyses evaluated the robustness of the findings, and also performed Regression analysis.

Insights

Exploratory Data Analysis

Our exploratory data analysis, utilizing a correlation matrix, reveals several key insights into the relationships between task performance, subjective experience measures, and demographic factors.

Analyzing the correlation heatmap shows a significant negative correlation between countdown completion time and scores ($r = -0.28$), indicating that participants who completed the task faster tended to score higher. Interestingly, no significant correlation exists between sorting task time and scores, suggesting that speed does not necessarily impact accuracy in more complex or organizational tasks like card sorting.

Additionally, we observed a moderate negative correlation between stress levels and enjoyment ($r = -0.36$), implying that increased stress negatively affects the enjoyment of tasks. Focus levels showed a positive correlation with countdown task scores ($r = 0.41$), supporting the hypothesis that greater focus improves task performance.

Demographically, age showed minimal correlation with task performance, indicating that the effects of music on task execution are consistent across different age groups. Also, the positive correlation between the time taken for both tasks ($r = 0.32$) suggests a consistency in task execution speed across different types of tasks for the same individuals.

These findings enhance our understanding of how individual characteristics and task-related behaviors interact and provide a basis for further analysis on the influence of background music on cognitive and emotional task responses.

The boxplot analysis (Image 1) of age distributions within the treatment and control groups reveals distinct demographic patterns. The control group exhibits a broader age range with a median slightly above 25 years, encompassing a wider variety from approximately 23 to 30 years in the interquartile range. This group also shows several outliers, indicating the presence of participants up to 40 years old, which adds a layer of diversity in terms of age-related experiences and potential cognitive differences. In contrast, the treatment group has a narrower age spread, with a median age around 24 years and an interquartile range tightly clustered between 22 and 26 years. This group also contains a few outliers but they are less extreme compared to the control group. The comparative analysis of these distributions suggests that while both groups generally consist of young adults, the control group includes a more varied age demographic. This difference in age distribution could influence the experimental outcomes, as age might affect task performance, stress tolerance, and music receptivity, thereby necessitating careful consideration in the analysis to accurately assess the impact of the treatment conditions.

Estimated Average Treatment Effect

The analysis of the Average Treatment Effects (ATE) provides insights into the impact of background music on task performance and subjective experiences (Image 2):

- **Task Performance**

  The effects of background music on task performance were mixed but generally positive. In the countdown task, music enhanced both accuracy and speed, with participants scoring higher by an ATE of +0.86 and completing the task faster by -15.39 seconds, indicating that music can boost cognitive processing. For the card sorting task, while scores improved modestly (ATE of +0.64), suggesting a beneficial impact on organizational skills, the time to complete the task increased slightly by +3.32 seconds, hinting that music might impede performance in more complex tasks that require greater cognitive engagement.

- **Subjective Experiences**:

  While music slightly increased enjoyment during tasks (ATE of +0.13), suggesting a positive emotional response, it also marginally raised stress levels (ATE of +0.12), indicating that it may introduce some tension under certain task conditions. Additionally, there was a slight decrease in focus (ATE of -0.11), pointing to potential distractions caused by music. These findings suggest that while background music can enhance the pleasure of task engagement, it might also complicate task execution by increasing stress and reducing focus.

The data indicates that while background music generally improves task accuracy and enjoyment, its effects on task completion time and focus can vary, potentially complicating task performance in more demanding scenarios. These findings highlight the importance of context in assessing the benefits and drawbacks of using music as a background stimulus in work or study settings.

Condition Average Treatment Effect

The analysis of Conditional Average Treatment Effects (CATE) reveals distinct differences in how males and females respond to background music during task performance (Image 3):

- **Performance Metrics**:

  In the countdown task, males experienced significant benefits from background music, which was evident in their improved scores (+2.43) and reduced task completion times (-4.29 seconds),

suggesting that music facilitated better focus and faster cognitive processing. In contrast, females exhibited a marginal decrease in scores (-0.22) and a substantial increase in task completion time (+30.61 seconds), which may indicate that music acted as a distraction for them. For the card sorting task, music had a positive but modest effect on male performance (+1.52), with minimal impact on their completion time (-0.27 seconds), pointing to a consistent benefit of music across tasks for males. However, females showed no change in performance (0.00) and a slight increase in task time (+1.19 seconds), further suggesting that music's effect might be more nuanced or less beneficial for females, potentially due to varying preferences or perceptual differences toward background music during tasks.

- **Subjective Experience**:

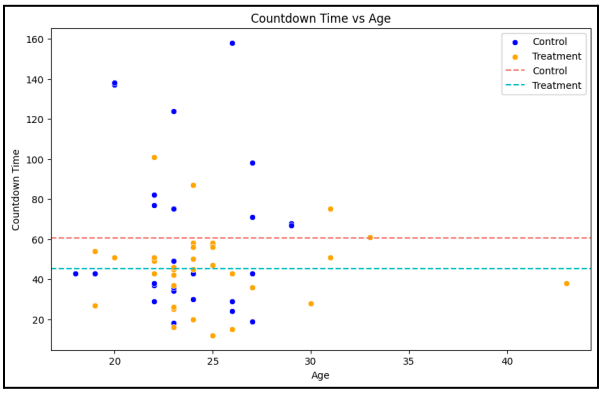
  Background music elicited varied responses between males and females during tasks. It increased stress levels in males (+0.83) but slightly decreased them in females (-0.12), indicating divergent emotional effects. While music enhanced task enjoyment more for males (+0.94) than for females (+0.23), it improved focus in males (+0.49) and slightly reduced it in females (-0.23). These findings highlight that music's influence on task performance can vary significantly between genders, enhancing certain cognitive and emotional responses while potentially hindering others.

The findings indicate that background music affects males and females differently during tasks, enhancing performance and subjective well-being for males but presenting mixed effects for females. This suggests that individual preferences and perhaps gender considerations should be factored into decisions regarding the use of music in work or study settings to optimize outcomes.

Statistical Analysis

T-Test Results for Treatment vs. Control

	Outcome Variable	t-score	p-value	Reject H₀	CI Lower	CI Upper
0	countdown_time	-2.058	0.044	Yes	-30.618	-0.155
1	countdown_score	1.033	0.3059	No	-0.781	2.508
2	sorting_time	0.546	0.5873	No	-8.419	15.055
3	sorting_score	0.89	0.3769	No	-0.859	2.133
4	stress	0.262	0.7942	No	-0.798	1.044
5	enjoyment	0.318	0.7516	No	-0.665	0.924
6	focus	-0.269	0.789	No	-0.888	0.673



	Dependent variable: countdown_time	
	(1)	(2)
Intercept	60.690***	60.690***
	(5.456)	(5.456)
treatment	-15.387**	-15.387**
	(7.478)	(7.478)
Observations	62	62
R^2	0.066	0.066
Adjusted R^2	0.050	0.050
Residual Std. Error	29.379 (df=60)	29.379 (df=60)
F Statistic	4.234** (df=1; 60)	4.234** (df=1; 60)
Note:		*p<0.1; **p<0.05; ***p<0.01

Our statistical analysis using independent T-tests revealed distinct effects of background music on task performance and subjective experiences. Significantly, music reduced the countdown task time (t-score = -2.058, p-value = 0.044), indicating enhanced speed without affecting accuracy, as no significant difference was found in countdown scores (t-score = 1.033, p-value = 0.3059). However, music did not significantly affect sorting task times or scores, nor did it impact subjective measures of stress, enjoyment, and focus, with all p-values exceeding 0.05. These results suggest that while music may improve efficiency in simple cognitive tasks, its benefits do not uniformly extend to more complex tasks or to altering subjective experiences such as stress or enjoyment. This highlights the task-specific influence of background music and underscores the importance of considering individual and task-related factors in its application. The same results were corroborated by linear regression analysis using the Stargazer library.

Statistical Power for Each Outcome Variable

	Outcome Variable	Effect Size (Cohen's d)	Power
0	countdown_time	−0.524	0.777
1	countdown_score	0.263	0.277
2	sorting_time	0.139	0.112
3	sorting_score	0.227	0.218
4	stress	0.067	0.064
5	enjoyment	0.081	0.071
6	focus	−0.068	0.065

The evaluation of statistical power and effect sizes for our outcome variables revealed varying levels of robustness in detecting the effects of background music on task performance and subjective experiences. Specifically, the analysis indicated that the study was well-powered (power = 0.777) to detect a significant decrease in countdown time, which was supported by a considerable negative effect size (Cohen's d = -0.524). However, the power to detect changes in countdown scores was low (power = 0.277) with a modest effect size (Cohen's d = 0.263), suggesting a limited ability to observe meaningful differences in this metric. Similarly, both sorting time and score, as well as measures of stress, enjoyment, and focus, exhibited low statistical power (ranging from 0.064 to 0.218) with negligible to small effect sizes (ranging from Cohen's d = -0.068 to 0.227). These results point to an overall underpowered study for detecting subtle changes in more complex tasks and subjective states, emphasizing the necessity for larger sample sizes or enhanced sensitivity in measurement methods in future research to fully explore these effects.

Heterogeneous Treatment Effects (HTE)

Heterogeneous Treatment Effects (HTE) occur when the impact of an intervention varies across different subgroups within a population. Rather than assuming that piano jazz music affects all participants uniformly, HTE allows us to determine who benefits the most, who is negatively impacted, and why. We analyzed heterogeneity with respect to gender using regression analysis but found no statistically significant difference in performance between males and females under piano jazz music. This suggests that background music does not systematically influence task performance based on gender in our study.

Challenges & Limitations

One limitation of our analysis was the challenge of collecting data from over 60 participants in person and administering the treatment. While we successfully gathered data for this sample size, scaling up would have required significantly more time and resources. To streamline data collection, we standardized Google Forms to gather demographic information and pre- and post-task responses. Another key observation was that significant results were primarily found in task performance, while other variables showed no

substantial effects. Additionally, one of the tasks designed to assess spatial and organizational skills appeared to be too easy for participants, potentially limiting its effectiveness in capturing meaningful differences in performance.

Conclusion

Our analysis reveals that background music enhances accuracy and processing speed in simpler cognitive tasks, as evidenced by improved countdown task performance. However, its impact on more complex tasks, such as card sorting, was less pronounced, with minor delays in task completion. Gender differences were observed, with males benefiting more from music in terms of performance and focus, while females experienced increased task completion times and slight reductions in focus. Although music slightly improved task enjoyment, it also elevated stress levels in some cases. These findings underscore the need for task-specific and individual considerations when implementing background music in cognitive environments. Future research should employ larger sample sizes and refine task complexity to better assess these effects.

Practical Applications

1. Provide an option to toggle music on/off in workplaces to accommodate different preferences.
2. Integrate custom jazz playlists and adaptive music features for different tasks into apps like Notion and Pomodoro timers to enhance focus and engagement.
3. Establish designated silent areas alongside music-friendly spaces in educational environments for greater flexibility.

Link to Google Drive:

https://drive.google.com/drive/folders/1iKz7yksWpoNRZfzFnZXkGCwun2lxz97w

Appendix

References:

1. Biasutti, Michele, and Elena Concina. 2024. "Jazz Piano Training Modulates Neural Oscillations and Executive Functions in Older Adults: A Pilot Study." *Music Perception* 41 (5): 378–94. https://online.ucpress.edu/mp/article/41/5/378/200674/Jazz-Piano-Training-Modulates-Neural-Oscillations. Last accessed March 4, 2025.
2. Hu, Xiaoxi, and Rachael D. Seidler. 2023. "Slower Tempo Makes Worse Performance? The Effect of Musical Tempo on Cognitive Processing Speed." *Frontiers in Psychology* 14: 998460. https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2023.998460/full. Last accessed March 4, 2025.

Generative AI declaration: We used ChatGPT for code generation, refining statements, and brainstorming ideas about the project.

Image 1

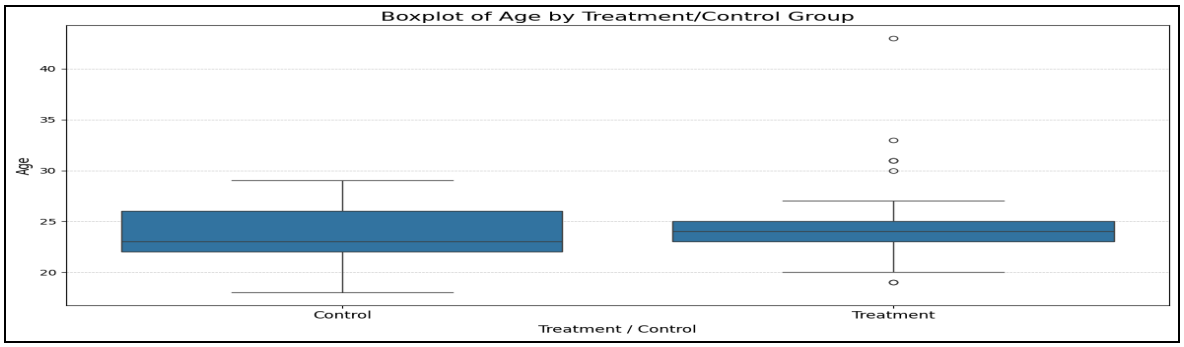


Image 2

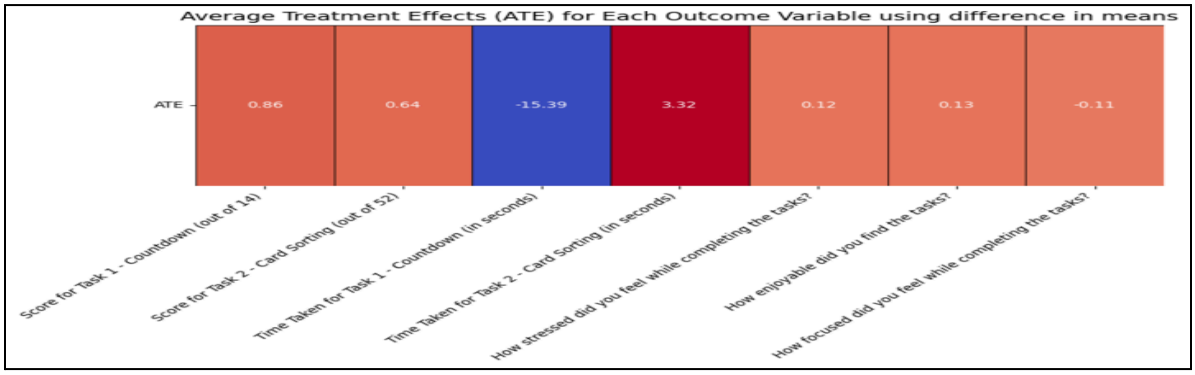
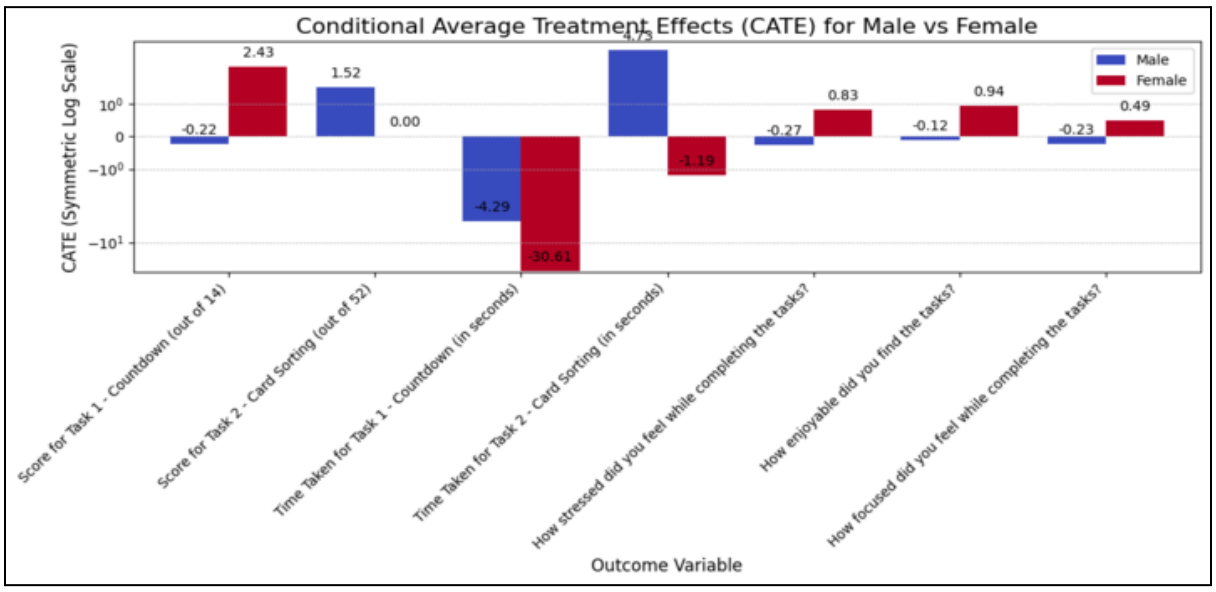
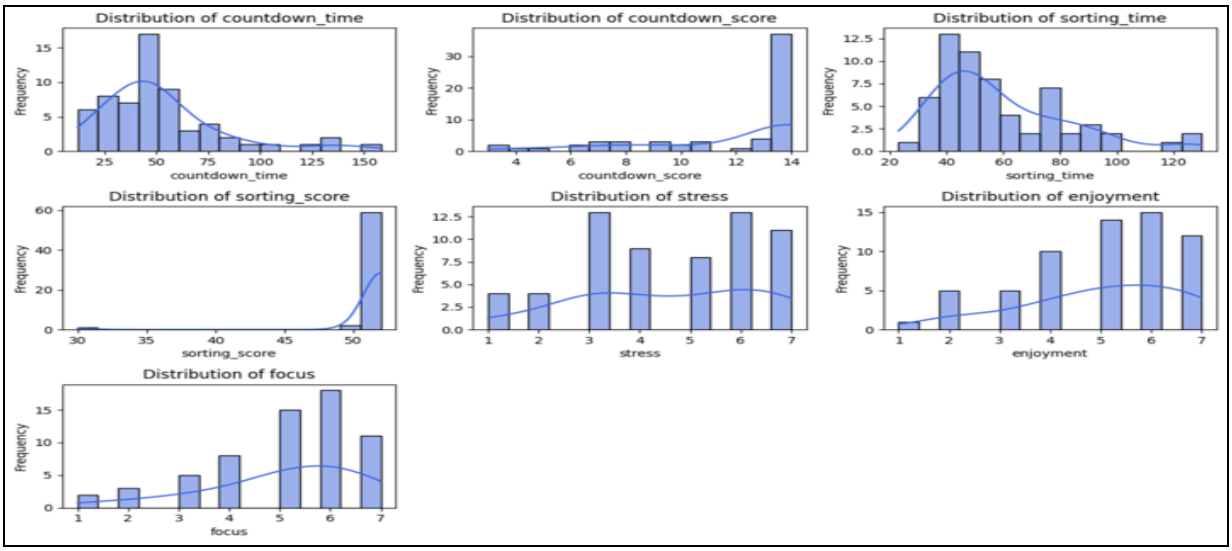


Image 3



Exploratory Data Analysis Summary:


Distribution of countdown_time
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Distribution of sorting_time
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