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The Effect of Music on Cognitive Tasks Among College Students: A Factorial Experiment

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Abstract

Music has been around since time immemorial, and it has both positive and negative effects. This study aimed to investigate the effect of different music presentations on the different cognitive tasks among college students. This study utilized an experimental within-subject 4x3 factorial design. The participants are twenty-one (21) college students. They undergo three memory tasks: memory, verbal, and arithmetic tasks while exposed to four (4) different music conditions: no music, instrumental music, English lyric music, and foreign lyric music. The researchers performed a two-way analysis of variance for repeated measures. Results showed no significant treatment main effect for music, $F(3, 60) = 1.649$, $p < .188$, $\eta p^2 = .076$ but has a significant treatment main effect for cognitive tasks, $F(2,40) = 118.448$, $p < .000$, $\eta p^2 = .86$, and significant interaction effect between music and cognitive tasks $F(5.35,105) = 2.629$, $p < .036$, $\eta p^2 = .12$. The significant interaction showed increased scores across different types of music in memory and verbal tasks but decreased scores in arithmetic tasks except with English lyric music and the no music conditions. Furthermore, simple main effects show that English lyric and foreign lyric music are best for memory and verbal task, respectively.

Keywords: music, cognitive tasks, instrumental, English lyrics, foreign lyrics

INTRODUCTION

Music has been around since time immemorial, and it has been used on many occasions. However, in our present technological day and age, music comes with gadgets. Music is always readily available, whether it be through the internet, mobile phones, laptops, computers, television, radio, cassette tapes, or vintage record players. In particular, music is very accessible to students of online learning. Most of their learning and studying time is on gadgets with music. With its right use, music improves performance; however, it also distracts attention and decreases performance among online students.

Students commonly listen to music for relaxation when performing stressful learning activities to reduce stress and anxiety. Music has been shown to improve cognitive function in some studies. Music training is associated with intelligence (Swaminathan et al., 2017), and music improves the reading comprehension of preadolescents with ADHD (Madjar et al., 2020). Repetitive frequency change or frequency modulation tone (such as Mozart's) improves spatial performance (Padulo et

al., 2020). Among surgeon trainees, preferred music played in the operating room during surgeries significantly improves their performance (Shakir et al., 2017).

Moreover, music demonstrated influences on some aspects of individuals. In the study of Nawaz et al. (2018), it was observed that preferred music and relaxing music helped change the emotional state of participants towards a positive state. Park et al. (2014) explained that there are differences in emotion processing between musicians and non-musicians, which supports the notion that musical training may alter the behavioral and neural processing of distinct emotions conveyed in music. On the other hand, music-making, which is often synchronized or tightly coordinated, in activities such as group drumming (Dunbar et al., 2012b), communal singing (Weinstein et al., 2016), and dance (Tarr et al., 2016) shows an influence towards forming social bonding. Music has proven to be an effective method of therapy and has been proven to boost mood significantly (Boothby, 2017). Moreover, music is better to be used prior to cognitive task performance to decrease cognitive and somatic anxiety while increasing self-confidence (Farmer, 2020)

While some studies have proven that music aids in students' academic performance (e.g., Singh, 2017), recent studies have revealed that not all music can elevate an individual's academic performance. A study conducted by Segaren (2019) found that listening to music with the presence of lyrics can hinder the individual from learning as the brain struggles to multi-task, comprehend lyrics, and focus on schoolwork and can decrease IQ by ten (10) points. Ironically, another study revealed that listening to music while playing video games can significantly boost performance (Tan, 2014).

Many studies have proven the effects of music on performance. It can either affect positively or negatively the performance. Thus, identifying what type of music presentation can increase or decrease performance is important. Most of the previous studies dealt with the effect of the music genre; however, this study focuses on the same music genre presented in different ways – instrumental, with English lyrics, and with foreign (French) lyrics. Although few studies were conducted on the different music presentations, the effect of foreign lyrics was not included. Thus, this study will explore the interaction effect and simple main effects of no music, instrumental, English lyric, and foreign lyric music on three (3) cognitive tasks, namely, memory, verbal, and arithmetic tasks.

Research Questions:

- Are there the main effects of music and cognitive tasks?
- Is there an interaction effect between the different types of music and cognitive tasks?
- Are there simple effects of music and cognitive tasks?

METHODOLOGY

Research Design

An experimental within-subject 4x3 factorial design was implemented in this study. In a within-subject factorial design, all of the independent variables (factors) are manipulated within subjects.

Each participant is tested in all conditions (Price et al., 2017). In this study, a group of participants underwent four (4) music conditions (no music, instrumental music, English lyric music, and foreign lyric music) and did three (3) cognitive tasks (memory, verbal, and arithmetic) for each condition.

Population and sampling technique

Twenty-one (21) college students enlisted, which came from Adventist University of the Philippines, Malayan Colleges Laguna, and other college institutions in the Philippines. All the 21 participants underwent the four conditions. Based on a guideline (*Choosing Between a Nonparametric Test and a Parametric Test*, n.d.), to run an analysis of variance for 2-9 groups, each group should have at least a sample size of 15. Thus this study qualifies for a parametric procedure.

Data gathering procedure

This study was conducted online. Participants were given informed consent to read and agree to participate in the experiment. Then, they were required to download Discord, a "Voice over Internet Protocol, instant messaging and digital distribution which is dedicated for creating communities" (Discord, 2021) which served as the researchers' virtual laboratory room. The participants then took the test for four (4) consecutive days synchronously together with the researchers to monitor and supervise the participants. Different musical bots such as Rhythm and Groovy were utilized in playing the necessary music needed for each specific treatment. The participants were exposed to the four music conditions per day (no music for the first day, instrumental music for the second day, English lyric music on the third day, and foreign lyric music on the fourth day) while taking the three cognitive tasks (memory, verbal, and arithmetic). After the participants had finished the different treatments, the researchers debriefed the participants.

Instrumentation

This study utilized one music/song presented in different ways (instrumental, English version, and the foreign/French version) as the treatment conditions. Furthermore, online websites that measure cognitive tasks (memory, verbal, and arithmetic) were also utilized to test the participant's abilities with the influence of the different presentations of music.

To control the music genre, only one song was used in this study. Pop music sung by Camille, a soundtrack of the Ratatouille movie entitled Le Festin (The Feast). The study utilized three versions of this song: the instrumental version, the English lyric version, and the foreign lyric version (French). A no music condition was added as the pre-test condition. A total of four treatment conditions were employed.

Human benchmark (2021) is a website that measures "abilities with brain games and cognitive tests." The Chimp Test was used to test the participants' memory levels with the highest score of 16 points. Exam English website (*Free English Level Test - How Good Is Your English? Which English Exam Is Right for You?* n.d.) was used to test the verbal task with the highest score of 15 points. The participants retook the same set of tests for this task; however, the right answers were not revealed by the website, instead only the scores. Finally, an arithmetic test from Varsity Tutor

on Arithmetic Diagnostic Tests (*Basic Arithmetic Practice Tests*, n.d.) was utilized with the highest score of 10 points. These cognitive tests were used as the measurements. There were four (4) different sets with the same difficulty level given to the participants. The participants took one (1) set of cognitive tests (memory, verbal, and arithmetic) for each music condition with a 24-hour interval per condition to control the carry-over effect and practice. Thus, a total of 4 consecutive days to execute the whole experiment.

Data analysis

The data gathered in this study were encoded and interpreted using SPSS. Two-way repeated ANOVA was utilized in measuring and identifying whether the presence of music has significant effects on the participants' cognitive tasks. This statistical analysis is employed when the same or matched cases take part in all of the conditions (Howitt & Duncan, 2017). Tables and line graphs were used to present the results.

RESULTS

To answer the research questions on the main effects and the interaction effect, a two-way analysis of variance for repeated measures was conducted. Table 1 shows the main effects and interaction effects among variables.

Table 1: Main and Interaction Effects Among Variables

Variables	**SS**	**df**	**MS**	***F***	***p***
Music	12.361	3	4.120	1.649	0.188
Tasks	1895.738	2	947.869	118.448	.000
Music*Tasks	28.294	6	6.942	2.629	0.039

The main effect of music on the scores was not significant [$F(3, 60) = 1.649$, $p < .188$, $\eta p^2 = .076$]. This is predictable since this experiment controlled the music genre and thus utilized only one pop music, Le Festin, but presented in different ways – instrumental, with English lyrics, and with foreign lyrics. This only proves that different presentations of one song do not have any significant effect on cognitive performance. Considering Figure 1 below, the scores are not significantly different in memory, verbal, and arithmetic tasks.

Figure 1: Main Effect of Music on Cognitive Tasks

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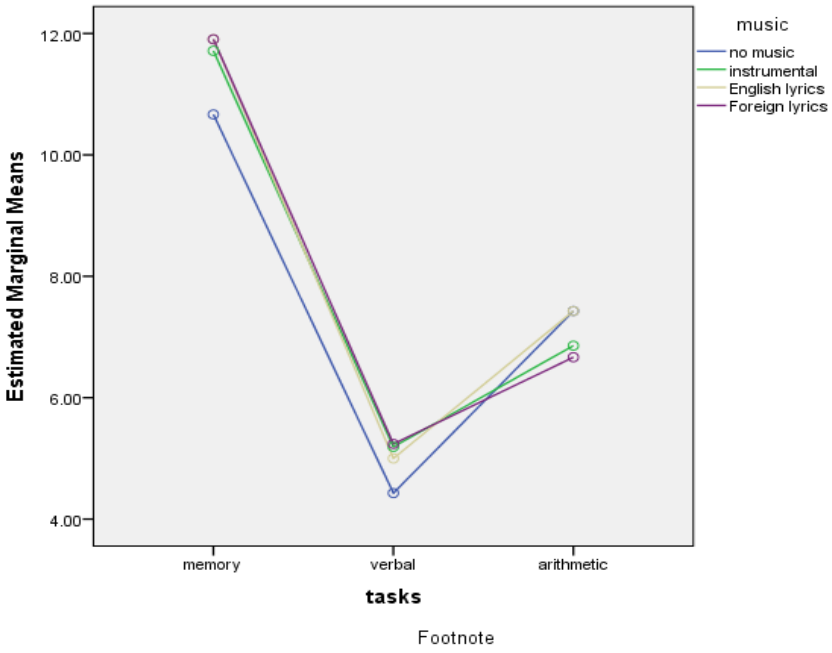

On the other hand, the main effect of cognitive tasks on the scores is significant [$F(2,40)$ = 118.448, $p < .000$, $\eta p^2 = .86$]. This is also predictable since the cognitive tasks employed measure different cognitive abilities, and the nature of the tests are different from each other (memory tasks, verbal tasks, and arithmetic tasks). A memory task is significantly different from a verbal task and other arithmetic tasks. As shown in Figure 2, cognitive tasks have marked differences in scores across the different music presentations (no music, instrumental, English lyrics, and foreign lyrics).

Figure 2: Main Effect of Cognitive Tasks on Music

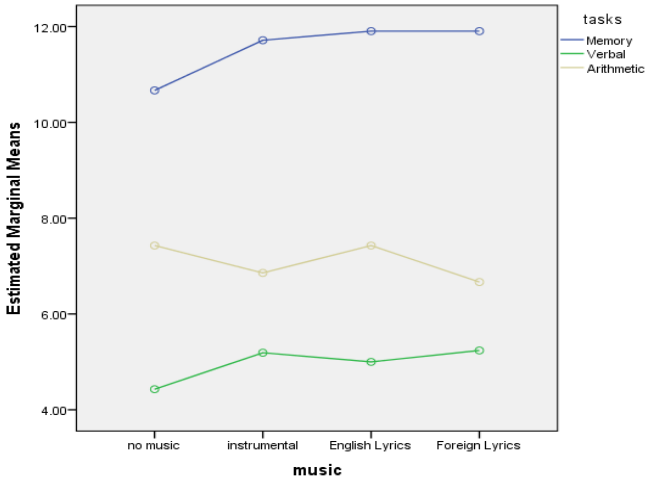

Table 1 also shows an interaction effect between the factors music and cognitive tasks with $F(5.35,105) = 2.629$, $p < .036$, $\eta p^2 = .12$. As shown in Figure 2, there is a crossover interaction

between the no music, instrumental, and foreign lyrics. This implies that no music and English lyric music yields better performance in the arithmetic task than with instrumental and foreign lyric music. To further understand the interaction effect, simple main effects were determined through pairwise comparison (see Appendix A). In the memory task, no music (M = 10.67) and the English lyrics (M = 11.91) yields a significant difference ($p < .05$). In the verbal task, no music (M = 4.429) and the foreign lyrics (M = 5.238) has a significant difference ($p < .011$). However, in arithmetic tasks, it has no significant difference across the different music presentations. The results imply that in doing memory tasks, it is best to have English lyrics than have no music at all. Similarly, in a verbal task, it is best to have foreign lyric music than having no music at all. In the arithmetic task, although it does not matter what kind of music presentation will be used, it is better (as shown in *Figure 2*) to either have no music or English lyric music.

Discussion

The purpose of this experimental research is to provide evidence of the main effects, interaction, and simple main effects of different music presentations to different cognitive tasks. This study contributes to the body of knowledge specifically on the positive effect of foreign lyric music. In this present generation, students are exposed to various languages in movies and music.

Despite playing the same song (Le Festin [piano cover], Le Festin [English cover], Le Festin [Original/French]), they have different impacts on the different cognitive tasks. English lyric music and foreign lyrics are effective on students' memory and verbal tasks, respectively. This contradicts the study of Flores (2021), wherein instrumental and no music was found to have no significant difference in spatial ability and reading comprehension. The discrepancy may be explained by the design used. This present study utilized a within-subject design, while Flores (2021) utilized a between-subject design. Furthermore, the instrument used in Mozart's classical music while in this present study was pop music. The genre could also have caused the difference.

Foreign lyric music, as this study found, is the best used for verbal tasks. This also contradicts the study of Threadgold et al. (2019), wherein foreign (unfamiliar) lyrics impaired creativity. In the same way, the result of this study on the effectiveness of English lyric music contradicts Oliver et al. (2020). The study found that music with lyrics impairs cognition in adults. The study further explained that the musical lyrics worsen performance by either interfering with selective attention processing of goal-relevant information or altering working memory capacity resulting in decreases in processing efficiency and performance effectiveness (Oliver et al., 2020).

In this present study, English lyric music shows a significant effect on memory tasks, and it did not worsen the participants' performance on other cognitive tasks (e.g., verbal and arithmetic). Also, this present study reveals an interesting effect of English lyric music on the arithmetic task. Participants have better performance in the arithmetic task in English lyric music and no music conditions than the instrumental and foreign lyric music, although not significantly. A study by Proverbio et al. (2018) found that rain sound is associated with better performance compared with no music in difficult arithmetic operations that may be due to enhanced cerebral alertness level induced by the auditory stimulation. This present study suggests that the English song lyrics may stimulate the brain. In a similar study with Oliver et al. (2020) above, another study agreed that

music has a negative impact on cognitive tasks (e.g., Moise & Adler, 2019) because it interferes the selective attention. However, people who have a better ability to control attention are protected from music-related distractions when completing academic-related tasks (Christopher & Shelton, 2017). Likewise, a study on neuroimaging may explain the discrepancy between the previous studies and this present study. Fedorenko and Varley (2016) reported that the brain's area for language is not that active when performing a nonlinguistic task like arithmetic, and thus, linguistic music (English lyric music) does not necessarily interfere with an arithmetic task. Furthermore, in the study of Cockerham et al. (2019), different musical backgrounds while performing a task with a higher cognitive load such as arithmetic did not yield a significant effect, as this present study also shows.

CONCLUSION AND RECOMMENDATION

As college students enter a paradigm shift from face-to-face classes to virtual classes, students are encountering different problems, some that can only be encountered in virtual classes. Music has proven to have significant effects on college students' tasks though there are many unexplored factors and variables that have not been tested. This study has established the effects of music on cognitive tasks among college students. Different presentations of music have different effects on college students' tasks. Specifically, English lyric music and foreign lyric music can positively impact memory and verbal tasks, respectively. The arithmetic task is better with English lyric music or no music at all. Students may use this information to improve their performance on their academic tasks.

Effects of music on the previous studies were inconclusive. There are many factors to be considered. Future research associated with music may explore different variables such as the beats per minute (BPM), the genre of music, and other subject variables may be considered such as learning styles, music preference, gender, mood, and the generation where participants belong. Moreover, future research that involves foreign lyrics or movies of foreign language on verbal comprehension and grammar is recommended. Finally, the researchers realized that one experimental study is far different from other studies with the variables being considered, such as differences in the music used and the differences of the cognitive tasks performed are not comparable. Thus, it is recommended to replicate this study in different cultures and ages of students with English as a secondary language to identify factors of similarities and differences.

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