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Article

The influence of music on lexical decision-making in adolescents

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SUMMARY

Reading comprehension and vocabulary retention are valuable assets in modern society. Studying these processes can aid in helping individuals improve these skills. The lexical decision task is designed to test aspects of vocabulary retrieval from short-term and long-term memory by prompting the subject to differentiate between words and non-words. From this task, researchers can determine the effects of certain stimuli on linguistic processing. Numerous studies have investigated the effects of music on various cognitive capacities, like memory and vocabulary. Not much research exists, however, that directly compares the effects of background music on reading comprehension and vocabulary retention as determined by the lexical decision task. In the current study, we hypothesized that participants would show greater accuracy rates on the lexical decision task when exposed to a selected piece of classical music while completing the task, as compared to completing the task in silence. We tested this hypothesis on a group of 25 participants who completed the lexical decision task once in silence and once while listening to Beethoven's "Moonlight Sonata, 1st Movement". Their accuracy was analyzed using a two-sample t-test. The results suggest a positive association between the effects of classical background music and improved accuracy. Our results indicate that listening to certain types of music may enhance linguistic processes such as reading and writing. Further research with a larger group of participants is necessary to better understand the association between music and linguistic processing abilities.

INTRODUCTION

The lexical decision task measures one's ability to differentiate between words and non-words in one's respective language (1). Research has tied the ability to differentiate words from non-words and the ability to recognize their meaning to one's literacy skills and vocabulary (2). During a lexical decision task, a subject is tested on their ability to retrieve vocabulary information from their long-term memory and react (e.g., clicking on a response pad). In completing this task, participants are required to draw upon their knowledge of the English language and quickly decipher whether or not they recognize a word among a series of letters presented (3). The task was originally designed by Roger Schaneveldt and David Meyer in the early 1970s in order to understand the organization of and the process of information retrieval from the long-term memory (1).

Various forms of memory recall, including one that is utilized during the lexical decision task, have been shown to vary in outcome in the presence of music compared to instances when music was not present (4). Music has been accredited with influencing mood, emotional arousal, and memory (5). Classical music has been recognized as having a calming effect that allows the brain to work more efficiently (6). Moreover, one study found that the genre of music greatly impacted one's memory abilities. In the study, three groups of participants—one listening to classical music, one listening to rap music, and one to silence—played a game of concentration (matching pairs of cards together). From this game, the researchers discovered that individuals exposed to classical music could complete the task more quickly and with fewer flips than individuals exposed to rap music or silence (7).

A different study tracked the impact of listening to classical music on academic performance and concluded that when students listened to music, specifically pieces from Vivaldi, Beethoven, and Chopin, during a lecture and periods of sleep, their academic success rates greatly increased. This increase in academic success was partially accredited to memory and recall abilities being enhanced by classical music (8). In addition, another study investigated the influence of different types of music sequences (rhythmic or textural) on syntactic and semantic processing in children. This study divided the children into two separate groups, one of which represented musical effects on syntactic processing and the other represented musical effects on semantic processing. For the semantic group, the children were asked to verbalize their imagination (anything they thought about) while listening to musical sequences, where half started with a rhythmic sequence and the other half started with a textural sequence. The responses were analyzed for word count, grammatical accuracy, and unique word usage. They found that the textural sound sequences promoted concept activation in the semantic processing group, as measured by the usage of more words, more unique words, and greater grammatical accuracy. For the syntactic group, the children were required to listen to music and then indicate whether a sentence provided by the researchers was grammatically correct. They then repeated the same experiment without music priming. They found that students who listened to the rhythmic music as priming performed better on the grammatical accuracy test compared to those who were not primed with music. These results suggest that rhythmic music has a positive relationship to syntactic processing. This study accredits their results to the arousal-and-mood hypothesis, which claims that music has the potential to influence a subject's mood and level

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of arousal and, consequently, can affect the performance of both adults and children on various cognitive tests. This hypothesis is consistent with their results demonstrating the effects of musical sequences on various forms of language processing (9). These studies suggest that classical music not only aids the retrieval of vocabulary from long-term memory but also has a direct impact on overall academic performance and linguistic processing abilities.

On the other hand, there is also research that offers the opposite perspective, arguing that music interferes with the completion of cognitive tasks. An example of such conflict is known as the Seductive Detail Effect, which suggests that, because music interacts with the brain's working memory, it qualifies as a distraction from any given cognitive task (5). A study that investigated this effect over multiple cognitive and memory tasks found a relationship between the presence of music and poor cognitive performance (5, 10). Some of these studies may have experienced a negative association between music and cognitive performance due to the selected music not qualifying as background music, and instead, causing distraction (5). Other research, however, supports that music does not qualify as a distraction if it is considered to be background music. Background music has no jarring tempo, lacks frequent octave changes, and often has no vocals or lyrics. Background music is often considered to be calming because it lacks intense ubiquitous features (tempo, pitch, timbre).

Many individuals use music as an aid while studying (unpublished observation), but it is unclear whether music has a practical use beyond recreation. Therefore, in conducting this study, we aimed to determine if academic processes like studying, reading, and memorization could be enhanced by listening to background music while completing the tasks. We used Beethoven's "Moonlight Sonata, 1st Movement," which we classified as background music because it contains no lyrics that may interfere with the literacy aspect of the lexical decision task. We hypothesized that if participants were exposed to the selected music while completing the lexical decision task, their performance would show greater accuracy when compared to when the task was performed during silence.

We tested a single group of students from Winchester High School between the ages of 16-18. Using a 4-button response pad, participants indicated whether one pair of words contained one or more real words or no real words at all. We aimed to distinguish between the participants' accuracy while listening to music and in silence during the lexical decision task to determine whether the presence of music during studying could improve academic performance.

RESULTS

In this experiment, each participant completed two tests of a lexical decision task, each containing 25 word pairs. For the first test, they completed the task in silence so as to establish a baseline. During the second test, the participants listened to Beethoven's Moonlight Sonata as they completed the task. Each test of the lexical decision task contained 25 word pairs, presenting a mix of both real and non-real words. The participants were asked to indicate whether or not a real word was present in each pair by pressing a button on a response pad. The first five word pairs were voided in order to give the participant time to adjust to the process of reacting in the time constraint.

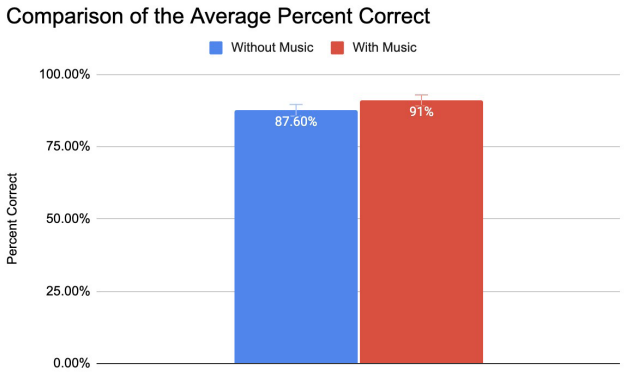

Figure 1. Comparison of the average percentage of word pairs classified correctly. The average percentage of correct responses (A when a real word was present, or D when no real words were present) across all 25 subjects with and without music with standard error bars. The rate of improvement from the test without music to the test with music was 2.72%.

We conducted a two-sample t-test to compare our paired data. A p-value of 0.08 was yielded, which was below that of the set alpha level of 0.1. This suggests that our hypothesis was supported—subjects performed better on the lexical decision task when listening to music than when completing the same task in silence.

We also averaged the percentage of word pairs classified correctly during each test (Figure 1). For test one, 87.6% of word classifications were correct. During test two, 90% of word classifications were correct, displaying a 2.4% increase in accuracy. The error bars on test one represent a 2.3% uncertainty. The error bars on test two represent a 2.1% uncertainty. Although there is a statistical difference between the two tests, the error bars heavily overlap, meaning that the difference is not statistically significant.

DISCUSSION

The purpose of this experiment was to observe how listening to classical music impacts accuracy in the lexical decision task. Using the iWorx IXTA and a four-button response pad, this study analyzed the success rates of subjects in completing this task in a silent environment versus when exposed to classical music during the task. The data collected were then compiled into data tables and run through a two-sample t-test that produced a p-value of approximately 0.08, which indicated that the null hypothesis could be rejected as the set alpha level was 0.1.

We found that subjects completed the lexical decision task with higher accuracy while listening to classical music than while completing the task in silence. The p-value that resulted from the two-sample t-test implies that rather than distracting subjects, classical music aided in the subjects' focus and led to better performance on the lexical decision task. This suggests that classical music positively impacts one's ability to process language visually during a lexical decision task test.

The rhythm of music has been found to differently influence syntax and semantic processing in children, which is likely a contributing factor to the success rates of those

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who performed the best during the second test of this task (9). It is possible that the music enhanced subjects' ability to draw upon their vocabulary-based memory, as a lexical decision task is a measure of vocabulary-based memory (9). Similarly, the audio features of the music likely had an impact on the success rates of the subjects during the second test. The music in this experiment qualifies as background music, as defined in the study, The Influence of Background Music on Learning in the Light of Different Theoretical Perspectives and the Role of Working Memory Capacity, meaning that the music does not have any disruptive tempo, unexpected octave changes, or vocal elements to the song in any capacity (5). These features likely influenced the positive results found in test two. From this, it can be assumed that the music did not serve as a distraction to those completing the task, as many other experiments and hypotheses, such as the Seductive Detail Effect, posit it would (5, 10). It is likely that the calming features of this music improved the emotional states of the participants, which aided in efficiency and memory recall (6). This cannot be concluded, however, because there was no method of recording the emotional state of the participants before, during, or after completing either test.

Some unexpected challenges that came up during the experiment involved subject error. Although all subjects were provided with the same explicit instructions, many struggled with completing the task correctly at the beginning of the first test. For example, a handful of subjects clicked the four-button response pad once for each word in the word pair. To account for familiarization with the test, subjects were notified if they were doing the task incorrectly following the first five word pairs, and the first five pairs of words were voided from all subjects' data from both tests. Additionally, some subjects did not look in the correct place for the words. Some viewed the word codes at the bottom of the screen, which were a part of the recording graph, and based their answers on that information instead of on the word pairs presented above. Those subjects were offered an opportunity to retake the tests, as they had no exposure to the word pairs in either Test One or Test Two.

Any conclusion requires further experimental support as not all conditions of the t-test statistical analysis were met. In order to conduct the two-sample t-test, there are assumptions that must be upheld by certain conditions, only some of which this experiment meets. The first condition is that the sample size is at least 30, which in this case, it was not. Our sample size was 25. The second condition is that the subjects were gathered randomly, which would indicate that the intelligence and cognitive abilities of the test subjects would be proportional to those of the school population as a whole. This condition was also not met during data collection due to lack of availability. The third assumption is that the data are independent, meaning that there are no opportunities for subjects to cheat or indicate methods for success to other subjects. This experiment did meet that condition; however, the test was performed over multiple days, meaning subjects may have had discussions about the experiment with other subjects who were set to complete the test at a later date. However, the computer automatically re-arranged the order of the word pairs even when the same test was performed, which would make it difficult to discuss the correct order of yes or no responses. Since the three previously mentioned conditions were not entirely met, we decided to proceed with caution, meaning that we cannot state a certain conclusion with statistical significance, but we can observe trends.

In the future, this experiment should be run with a larger variety of participants chosen at random to ensure a completely valid statistical analysis. Similarly, subjects should be told that at any point if they do not understand the given task, they should indicate so before completing the experiment. The study should also be run with different kinds of music (e.g. rap) to analyze the effects of doing so as compared to listening to classical music or in silence. If repeated, experimenters should consider alternating the usage of music between tests one and two to prevent participant improvement between the rounds, which could skew the data.

The goal of this study was to determine whether the presence of music can aid in academic performance by improving memory retrieval and further studies should aim to strengthen the observable trend in this data, that the presence of music can aid in vocabulary-based memory.

MATERIALS AND METHODS

Study Participants

Participants were 25 individuals (female n=23, male n=2) ages 16–18 who were all recruited from Winchester High School. They were selected using convenience sampling, meaning that they were chosen due to past contact/relations with the research conductors. There were no specific traits, common denominators, or individual requirements necessary for study participation. Each participant was emailed and asked to participate in a lexical decision task. The age range (16–18) was selected to provide consistent data in terms of brain and reading development skills. All participants were able to speak and read English. Participants who had visual correctors, such as glasses or contact lenses, were required to wear them during the experiment. To build technological familiarity, participants were asked to read two words that were centered in the middle of a computer screen and press a response button labeled A or D. No technological skills were required because no direct computer program interaction occurred. All participants were asked to complete the same task in the same order—first with no music (Test 1), then with music (Test 2). The experiment used the same subjects for both the control and experiment tests because the subject group was small, meaning that dividing subjects into two groups could have created one group with higher intelligence or a language familiarity bias, leaving the other group disadvantaged. The research protocol was approved by a scientific review committee that was established to evaluate this study prior to experimentation. Participants were required to complete a consent form and were also required to attain parental consent if they were a minor.

Lexical Task Test Administration

Pre-existing lexical task word pairs that were available through the iWorx Lexical Decision Task test were used to test participants. Test One and Test Two were used, each containing 25 word pairs. The word pairs used in this study varied in their correlation to each other. For example, a word pair may include the words [Murder, Knife], or they could include [Bird, Desk]. Though the same tests were used for each subject, the computer randomly generated an order,

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so no two participants had the same word pair order. Before the participants began the task, they were provided verbal instructions. Participants completed two tests of 25 word pairs, and their accuracy levels were recorded. For one or more real words, participants were told to press 'A', and for two non-words, to press 'D'. They performed the first test in silence. They performed the second test with headphones on, listening to "Moonlight Sonata". Participants were also told that the first five questions of both tests were their opportunity to familiarize themselves with the technology and response pad. They understood that they would not count towards the results. Participants were given about 1 minute between tests, during which the directions were not repeated.

Control Test (Test 1):
During the first lexical task test, participants were shown a pair of words on a computer screen and were required to press 'A' for one or more real words or 'D' for two non-words. For example, [Churkey, Cream] would be 'A,' and [Dimit, Lenk] would be 'D.' Each word pair was shown for one second. A two-second white screen would follow each word pair before the next word pair appeared. This process would repeat for 25 word pairs total. Each person's data was saved under "Subject # - Lexical Baseline" to keep data anonymous.

Audio-based Test (Test 2):
During the second test, participants were required to plug their own headphones into an audio source. Researchers found the Beethoven Collection's recording of Moonlight Sonata (1st Movement) by Beethoven on YouTube and played it at 50% volume to ensure the correct recording was played at the proper volume. As the music played, the participants were simultaneously required to complete the second lexical task test, repeating the same testing process as in the control test. Each person's data was saved under the title "Subject # - Lexical Test" to keep data anonymous.

Measures

The outcome variable in this experiment was the accuracy of the participants' task results, comparing the completion of the lexical task completion in silence to the completion of the lexical task while listening to music. Their responses were scored for correctness. For all participants, the first five word pairs were voided from the overall results to account for the learning curve each subject experienced. This means that although 25-word pairs were recorded, only 20 were used in data analysis. The number of correct responses was recorded for each test for each subject.

Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
# of Correct Responses: Test One	20	16	17	20	20	17	19	20	19	17	16	20	11	19	14	15	17	18	20	19	16	15	19	15	19
# of Correct Responses: Test Two	19	19	20	20	19	19	19	19	18	20	19	20	15	15	19	11	20	17	19	19	19	14	19	18	19

Table 1. Number of Word Pairs Classified Correctly. The number of correct answers (A when a real word was present, or D when no real words were present) out of 20 in test one, silence, and in test two, accompanied by music, by subject number.

Analysis

The number of correct responses out of 20 was calculated as a percentage for each participant for the time the task was performed without music and the time the task was performed with music. For all 25 subjects, the percentages for the trial without music were entered into List One on a TI-84 graphing calculator, and the percentages for the trial with music were entered into List Two on the same TI-84. To measure our results, we compiled the data into a two-sample t-test and derived a p-value. The p-value yielded from the two-sample t-test indicates the probability that the pattern of improvement observed could exist if the null hypothesis is true. The alpha level set for this test was 0.1.
The experiment was run on the data compiled from **Table One** with the selection of pooled because we were combining data across subjects and trials to analyze and the selection of comparison <μ2 which indicates that our research expected the second trial to yield greater accuracy results than the first trial.

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