How Do Different Auditory Environments Affect Memory in University Students?

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Introduction

Memory is the process of taking in information from the world around us, processing it, storing it and later recalling that information, sometimes many years later (MEMO 2015). The human brain is an incredibly complex organ, and memory is a multifaceted phenomenon with different types and mechanisms that occur inside it. The first mechanism that occurs is called encoding, in which sensory input is converted into neural code so that it can be stored in the brain (The Human Memory 2022). From there, the neural codes can be stored in sensory memory, short-term memory, working memory, or long-term memory depending on its character (Camina and Guell 2017). This information can be retrieved when needed through neurons. The basic unit of the brain is the neuron, and information is transmitted between neurons through synapses (Brain Basics 2023). When we learn or experience something new, the connections between neurons are strengthened through a process known as synaptic plasticity (Owens and Tanner 2017). This involves changes in the strength of synapses, making them more or less likely to transmit signals.

Memory plays a vital role in our lives. Not only is it important for learning, as it allows us to acquire and retain new information, but it can also help us in problem-solving. Memory is a cornerstone of cognitive function, influencing various aspects of our daily lives. It enables us to learn, adapt, communicate, plan for the future, and construct a sense of self and identity, all of which are essential for personal and societal functioning. Additionally, memory plays a large role in the lives of students. As students, going to classes, retaining the new information provided by the lecturer, going home to study said material, rehearsing the information in hopes of retaining it in your brain, and recalling the material for exams is a regular activity. Usually, if you prepared well beforehand and are pretty familiar with the information, the act of memorizing benefits you in your academic studies. However, certain activities you partake in whilst studying may affect your memorization skills, which may hinder or benefit your performance on an exam.

Factors such as age, health conditions, genetics, sleep, and substance use are known to affect memory (Buckner 2004). Furthermore, different distractions also influence one's capability to memorize. Recent studies have investigated the effect of echoic memory on cognitive ability (Cherry 2023). Echoic memory is the ultra-short-term memory for things you hear (Contributors 2021). It was seen that after a noise is produced, sound waves are picked up by the human ear and affect the auditory nerve (Jafari et al. 2019). This turns the sound waves into electrical impulses transmitted to the brain. Once the sound reaches the brain, an echoic memory is formed. The brain processes this information and then stores it in the primary auditory cortex (Jafari et al. 2019). The brief storage in echoic memory gives the brain time to interpret the sound and determine its characteristics. The sound may be transferred into working memory for further interpretation. Echoic memory can be produced when listening to music, environmental noises, or even talking to a friend. The process of creating echoic memory can

distract you from the task at hand without you even noticing, since this subconscious mechanism is always on. Therefore, we do not even realize that we are forming echoic memories, hence why determining its effects can be difficult, but interesting.

There have been studies in the past that have evaluated the effect of different echoic memories on cognitive abilities, however there has not been much discourse about their effect on consolidating memory alone. Specifically, the effect of listening to music (echoic memory) while memorizing material has not been investigated thoroughly. A similar study to the study we conducted examined the effect of music on the memorization of rhyming poems. (Musliu et al. 2017). As students, we recognize that the probability of a university student memorizing poems is quite low. Therefore, we investigated whether listening to music will affect the ability of university students to memorize simple words, trying to mirror the way students need to memorize vocabulary words in upper year courses, which do not always have the advantage of being able to rhyme with each other.

Therefore, our study aimed to determine whether different types of auditory environments affect the memorization skill of university students. Specifically, we sought to investigate the effect of silence, non-lyrical (instrumental), and lyrical music on the memorization of university students. We predicted students to achieve the highest memorization score when memorizing words in complete silence, decreasing the probability of the formation of echoic memory. Following silence, we expected the students to have higher memorization scores while listening to non-lyrical compared to lyrical music. In other words, we hypothesized that if listening to different types of sounds while studying affects memory, then participants listening to no or non-lyrical sounds will demonstrate increased memory compared to individuals listening to lyrical sounds.

Material and Methods

Data Collection

Our study involved 21 participants aged 19-24, randomly selected from Thompson Rivers University. Three consecutive memory tests were conducted to analyze the influence of different auditory environments on memory. All three conditions consisted of participants wearing noise-canceling headphones while memorizing a list of 18 words related to color, animals, and sports, which were different for each category (see appendix). The list was presented on a laptop screen for 90 seconds. After 90 seconds, the laptop was closed, and participants were then given another 90 seconds to recall as many words as possible while continuing to be exposed to the selected sound.

The silence memory test was conducted first. For this test, no sound was played in the headphones. The silence test was followed by the non-lyrical memory test. In the non-lyrical

memory test each participant listened to "The Way" by Florian. Lastly, we conducted a lyrical memory test using the song "Cake by the Ocean" by DNCE. All the responses were recorded in an excel spreadsheet. Once we collected the written responses from all the participants, we counted how many words the participant was able to recall and scored them out of 18.

Statistical Analysis

Before conducting a statistical analysis, we transformed the data into two columns. The first column represented the explanatory variable- type of music (silence, non lyrical, lyrical). The second column included the response variable, memory, which was the score out of 18 recorded for each trial. The datafile was saved as a csv and then imported into R studio where the scores were converted into percentages which allowed us to analyze and graph the data. To represent the variation within and between the different memory tests, a box plot was created in R. Additionally, to show each individual's score on the memory test, a scatter plot was generated in R. For the scatter plot, the data was organized in excel into separate spreadsheets. Each spreadsheet, dedicated to a specific memory test, contained three columns: participant, type of music and score. These files were then uploaded in R as csv files.

To assess the variation among the different categories to the variation within the categories, an ANOVA statistical test was conducted in the R. Additionally, in order to determine which category's scores differed, a Tukey HSD statistical analysis in R was conducted. These analyses aimed to determine whether the varied auditory environments, represented by different sounds the participants were exposed to, had a discernible impact on their ability to memorize the presented word lists.

Results

Different types of music appeared to have no effect on memorization (Figure 1) ($F_{2,60}$=0.211, p=0.81). Additionally there is more variation within the three categories than between the categories (Figure 2). Participants scored 2.645503 higher when listening to non-lyrical music compared to lyrical music (CI: -7.140699-12.43170, p=0.7932746). Additionally, participants scored 1.322751 higher in the silence trial compared to the lyrical trial (CI: -8.463450-11.10895, p=0.9435520). Lastly, individuals scored 1.322751 higher in the non lyrical trial compared to the silence trial (CI: -11.108953-8.46345, p=0.9435520).

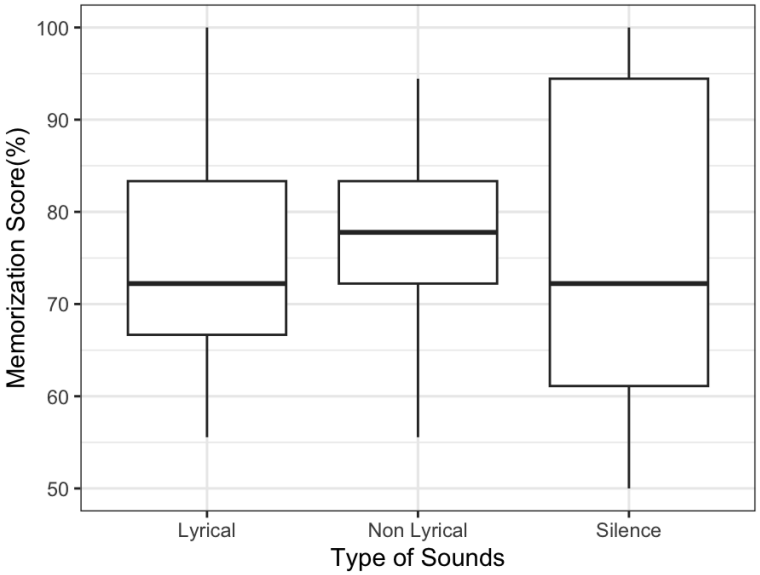

Figure 1. Memorization does not differ over different types of sounds. A memorization test was performed for each of the different types of sounds which include lyrical, non lyrical, and silence. Participants were required to recall a list of 18 words after studying it for 90 seconds while being exposed to the selected sound type. Memorization among individuals varies the most in the silence trial. Non lyrical sounds had the highest median, and lyrical and silence had similar medians (n=21).

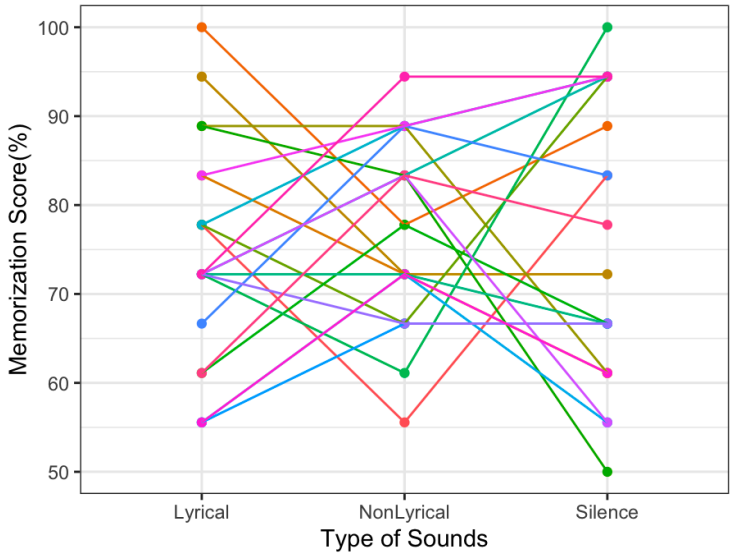

Figure 2. **Memorization scores had greater variation within the categories than in between three categories.** A memorization test was performed for each of the different types of sounds which include lyrical, non lyrical, and silence. Participants were required to recall a list of 18 words after studying it for 90 seconds while being exposed to the selected sound type (n=21).

Discussion

There is limited information regarding how echoic memory consolidation influences the cognitive processes when university students are studying or memorizing information. Therefore, our research project sought to investigate the impact of different auditory environments (a form of echoic memory) on memorization skill. However, our findings did not reveal a significant difference in memorization across our three memory tests, suggesting that various types of music have no effect on memorization.

Contrary to our results, a previous study which examined memory concluded that memorizing while listening to music—lyrical or non lyrical—is less effective than memorizing in silence (Musliu et al. 2017). In this study, they used a similar study design in that they tested how university student's ability to recall rhyming poems was affected by different sounds (Musliu et al. 2017). They found that without the distraction of music, students were able to code, memorize, and recall rhyming lines of poems more successfully (Musliu et al. 2017).

Potential explanation as to why our results were contradictory to our initial predictions and hypothesis is the influence of a confounding variable– participant's individual preferences for studying with or without music. Since each individual perceives sounds differently, the level of distraction caused by music may vary among participants (Kliuchko et al. 2015). It is possible that individuals accustomed to listening to music during study sessions might have developed a greater ability to concentrate in the presence of auditory stimuli.

Additionally, students tend to memorize information when an exam is forthcoming. In future studies, examining different individual scores on their exams after studying in a specific auditory environment may lead to a more accurate representation of real life experiences. Furthermore, the words we selected for students to memorize were simple, common vocabulary words. In real life, university students are less likely to be asked to memorize the names of colors, sports, and animals. However, for simplicity we chose to give them simple words to memorize. In future research increasing the sample size can be beneficial. Larger sample sizes provide more data points, which can help reduce the variability in the data. As the sample size increases, the sample mean becomes a more reliable estimate of the population mean.

Our research project set out to examine whether different auditory environments play a role in university students' memorization. Although our results were not significant, listening to non-lyrical music produced a higher memorization score for students relative to the other sounds, but in order to determine if this is a trend, a larger sample size would need to be examined. We also acknowledge that personal preferences, cultural factors, and the nature of the task at hand all play a role in determining how auditory environments influence cognitive processes. In future studies, recording the sleep and nutrition of participants could also provide us with a better understanding of how well their memory will be since these factors impact memory in humans.

Overall, university students should experiment with different auditory environments to identify the conditions that work best for their own cognitive performance and memory tasks.

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Appendix

Table 1. Word lists consisting of color, animals, and sport that were used for the three memory tests.

Silence	Non Lyrical	Lyrical
Swimming	Deer	Bird
Bear	Indigo	Boxing
Kitten	Volleyball	Monkey
Skiing	Dog	Bear
Biking	Golf	Javelin
Silver	Blue	Moose
Violet	Ivory	Whale
Javelin	Soccer	Biking
Orange	Red	Yellow
Climbing	Wolf	Hiking
Teal	Yellow	Baseball
Badminton	Purple	Kitten
Skating	Horse	Tennis
Pony	Cow	Green
Fish	Emerald	Purple
Monkey	Baseball	Pink
Bird	Pink	Brown
Chicken	Cat	Hockey

```
> Finaldatatable <- select(Biometric_Term_Project, "TypeOfMusic", "Score")
> # Ran an ANOVA to examine the effects of the type of music on memorization.
> ANOVA <- aov(Score ~ TypeOfMusic, data = Biometric_Term_Project)
> summary(ANOVA)
             Df Sum Sq Mean Sq F value Pr(>F)
TypeOfMusic   2     73   36.74   0.211   0.81
Residuals    60  10447  174.11
> # Perform Tukey's HSD test for post hoc analysis
> TukeyHSD(ANOVA, "TypeOfMusic")
  Tukey multiple comparisons of means
    95% family-wise confidence level

Fit: aov(formula = Score ~ TypeOfMusic, data = Biometric_Term_Project)

$TypeOfMusic
                          diff        lwr      upr     p adj
Non Lyrical-Lyrical  2.645503  -7.140699 12.43170 0.7932746
Silence-Lyrical      1.322751  -8.463450 11.10895 0.9435520
Silence-Non Lyrical -1.322751 -11.108953  8.46345 0.9435520
```

Figure 3. Raw data of R-script outputs.