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**Faculty of Applied Science and Engineering**  
**MIE237**  
*Statistics*

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Project Title	The Influence of Background Music and Text Formatting on Memory and Comprehension
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***Original Authorship Statement***

*The contents within the following report for MIE237: Statistics have been solely created by members of Group 20. All external sources used are publicly available, and their creators have been properly acknowledged. All participants in the data collection process gave direct consent for the team to use their ratings and feedback. This statement confirms that the group members upheld the University of Toronto's academic integrity policies in the creation of this report.*

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## **1.0 Introduction**

The research question guiding this experiment is: What is the effect of background music and text formation on memory recall? The purpose of this experiment is to explore the relationship between text formatting and background music and their impact on short-term memory and word recall. The study design, composed of proposed experimental procedures and data collection methods, was informed by background research and a literature review.

## **2.0 Background Research**

Several studies have shown the effect of background music and different text visualization formats on short-term memory recall, comprehension, and cognitive performance. These studies will further inform the team's hypotheses and research questions.

### ***2.1 Influence of Background Music on Memory Recall***

Studies have shown that background music may have a negative impact on short-term memory recall [1] [2]. Alicia Sheel conducted a study on 45 university students who were tasked to study a text and answer questions while listening to different background music: relaxing music, a personal choice of music, and finally, just silence. The results showed that the highest memory recall scores were achieved in the silent condition, followed by the relaxing music condition, and finally, the personal choice of music. She claimed that “complete silence allowed better concentration and remembering”, leading to a better recall of the elements in the provided texts. Another study [2] split up 200 medical students into 4 groups who were exposed to different backgrounds: no music, instrumental music, country music and rock music and were instructed to memorize a list of given words in a specified time slot to assess their short-term memory. Results showed that participants who had no music scored the highest, followed by rock music, instrumental, and then country music. The authors claimed that “reading comprehension was impaired when the lyrical music was played,” which led to a decrease in memory recall. Contradicting this, however, another study conducted by Alessandra S Souza and Luís Carlos Leal Barbosa concluded that instrumental music did not credibly hinder or improve performance on the cognitive tasks conducted in the experiment, essentially having the same results as silence [3].

In addition, one study examined the impact of various types of music on students' reading comprehension. 90 college students were divided into 2 even groups based on listening habits (listeners and non-listeners). The students were provided with music in their native language, a foreign language, and no music. The reading comprehension performance decreased when listening to music with lyrics compared to no music [4]. In addition, music with native language lyrics had the strongest negative effect on the students' comprehension [Frontiers]. Reading comprehension was more negatively affected when the lyrics of the music matched the text language. This led to the conclusion that there is competition between processing lyrics and reading text [4].

## ***2.2 Influence of Text Formatting on Memory Recall***

Regarding text visualization and formatting, studies showed that list formatting has an impact on word recall [5]. Frank Jansen's study conducted five experiments to explore the influence and effectiveness of bulleted lists over enumerations of paragraphs on recall. The study showed that when readers read a series of words in a bullet list, they were "more aware of the number of components the series comprises and [were] able to recall more of the individual components than the readers of the enumeration [did]" highlighting that the effect was stronger when the list was homogeneous, meaning all the words were of the same theme [5]. The study also concluded that although bulleted lists were better for memory recall, longer lists were unappealing to users and discouraged them from engaging with the text, decreasing their word recall.

In addition to this study, another paper explored the influence of interword spacing on reading comprehension. The research investigates how removing spaces between words affects reading speed, comprehension, and cognitive processing compared to traditionally spaced text. The participants were 11 university students, 19-65 years old, and had a mix of academic levels. The students were given four adapted Singapore folktales to read, two versions of each story (regular spacing and Scriptura Continua). The participants had their reading patterns measured through eye tracking and were also given comprehension tests using multiple choice and short answer questions. It was then concluded that participants spend 27% more time initially parsing unspaced text, with a 33% increase in total reading time for Scriptura Continua texts[6]. 7 participants performed better on Scriptura Continua texts, and there was an overall mixed

outcome with the results, but trended towards there being an improved comprehension with Scriptura Continua[6]. It was concluded that spacing may not be necessary for comprehension in English and increased cognitive effort in reading unspaced text may lead to better retention[6].

### **3.0 Proposed Methods**

The data the team intends to collect will be the Participants' scores of accuracy for word/phrase recall, as well as the Participants' time for word recall.

#### ***3.1 Independent and Dependent Variables***

The first independent variable the team will have is the types/levels of background music. This will allow the team to assess how different musical backgrounds affect short-term memory recall since many studies have shown that music has a negative impact on students' cognitive performance [1] [2] while others have proven the opposite [3]. This will be separated into different tiers: silence, instrumental music, and popular lyrical music. Instrumental music was defined under the Classical genre of music, more specifically "*The Four Seasons: 'Winter' [Concerto in F minor op. 8 no.4]: Allegro non molto*" by Antonio Vivaldi and Anthony Marwood. This song has a tempo of 154 BPM. Lyrical music was defined to be a popular pop song, more specifically, "*Uptown Funk*" by Bruno Mars. This song has a tempo of 115 BPM. Both songs were played at 80-83 dB for the participants while wearing over-ear headphones. The other independent variable the team will have is the formatting of the text provided to the participants. The first format will be bulleted lists of words and short phrases they will be asked to remember. The second format will be the same words and lists but in a comma-separated paragraph format. This independent variable will determine whether visual formatting influences the amount of information participants can retain, comparing structured lists to a continuous prose.

The first dependent variable is the accuracy of word/phrase recall from the participants. The second dependent variable is the recall time of the participants. These two variables will allow the team to measure the different performances of the participants to evaluate the impact of background music and visual formatting on short-term memory recall.

### ***3.2 Description of Hypotheses***

#### Null Hypothesis ( $H_0$ )

The Null Hypothesis states that there is no significant effect of background music type (including silence, instrumental, and lyrical) or text format (bulleted list or comma separated paragraph) on participants' accuracy when recalling text from memory or recall time

#### Alternate Hypothesis ( $H_1$ )

The Alternate Hypothesis states that silence will result in higher recall accuracy than lyrical/instrumental music, and bulleted lists will improve accuracy compared to paragraphs.

#### Interaction Hypothesis ( $H_2$ )

The Interaction Hypothesis states that there will be a negative effect of lyrical music on recall and will be stronger for comma-separated lists.

### ***3.3 Description of Proposed Experiment Procedures***

The study will involve 16 university students as participants. Participants should be fluent in English and have no hearing impairments. The experiment will be conducted using the following apparatuses:

- A list of words and short phrases presented on paper
- Headphones to play background music at a controlled volume
- A stopwatch to record participants' response time
- A data collection sheet to record participants' responses and accuracy of word recall

Prior to conducting the experiment, participants will be briefed on the instructions and will be asked to confirm their consent to participating. Participants will complete six trials for each combination of:

- Silence, bulleted list
- Silence, comma-separated list
- Instrumental music, bulleted list
- Instrumental music, comma-separated list
- Lyrical music, bulleted list

- Lyrical music, comma-separated list

Participants will be presented a list of 5 words and 5 short phrases ( $\leq 4$  words) for 60 seconds. The bulleted lists and comma-separated lists will use identical word order and structure, with five single words, four two-word phrases, and one three-word phrase. They will also be given a 30-second break between trials (once they are finished writing their answers down). The list will be either bulleted or comma-separated, and the background music will be either silent, instrumental, or lyrical, depending on the trial. Each participant will listen to the same 2 songs for the specified trials. The participant will then be asked to recall as many words or phrases from the list as possible while being timed and scored for accuracy. Participants will be required to write the exact word or phrase to receive the point, synonyms will not count towards correctness. The list of words and phrases will change for each trial but maintain the same level of difficulty to ensure that the participant is not recalling words from previous trials since the experiment aims to reflect impacts on short-term memory.

#### 4.0 Results

After testing all 16 participants, the collected results from the different trials were organized into an Excel sheet. Each sheet contains the different trials that were being tested and includes five columns: the number of the participant, score out of 10, response time, music type, and format. In order to visualize and analyze the obtained data, the R programming language was used.

A Shapiro Wilk Test was done to test whether the recall scores of the 6 conditions were normally distributed. Figure 1 shows that five out of the 6 p-values are above 0.05, showing that there is no violation of normality. One condition's p-value was 0.0364, which is only slightly below 0.05. Given that the other five conditions were normally distributed, the team proceeded with a 2-way ANOVA test.

Music	Format	W	P-value
Instrumental	Bulleted	0.889	0.0546
Instrumental	Comma	0.891	0.0574
Lyrical	Bulleted	0.942	0.375
Lyrical	Comma	0.977	0.937
Silence	Bulleted	0.942	0.372
Silence	Comma	0.878	0.0364

Figure 1. Shapiro-Wilk Test to test for Normality

Levene's Test of Homogeneity of Variances was also conducted to ensure that the assumption of equal variances was met. The result from this test, summarized in Figure 2, showed a non-significant result with  $p = 0.08039$ . This suggests that the homogeneity of variance assumption was satisfied across all six conditions.

Source	df	F-value	p-value
Group	5	2.0406	0.08039
Residual	90		

Figure 2. Levene's Test for homogeneity of variance

A two-way ANOVA test was then performed to examine the effects of Music Type (Silence, Instrumental, Lyrical) and Format (Bulleted, Comma) on participants' recall scores. Figure 3 shows the ANOVA table.

	Df	Sum Sq	Mean Sq	F-value	Pr(>F)
<b>Music Type</b>	2	6.02	3.010	1.0026	0.3626
<b>Format</b>	1	2.34	2.344	0.799	0.3738
<b>Music Type: Format</b>	2	19.31	9.656	3.291	0.0417
<b>Residuals</b>	90	264.06	2.934		

Figure 3. ANOVA Table to compare Music Type and formats of the experiments

The main effects observed from this table are:

1. Music Type: A  $p\text{-value} = 0.3626$  is above 0.05, so there isn't any reliable difference in recall scores among the three music categories (Silence, Instrumental, Lyrical) when they are considered on their own (no word Format taken into consideration). The small eta-squared value (0.02) also shows that the type of music being played (or none) explains only 2% of the variance in the participants' recall scores, which is a small effect size. Looking at only what music is playing shows no evidence of impacting how many words/phrases a participant can recall.

2. Format: The p-value = 0.3738 is above 0.05, so there is no statistically significant difference between the two text format conditions (Bulleted vs. Comma-Separated lists) when recalling words by themselves. The small eta-squared (8.80e-03) shows that the text format on its own explains <1% of the variance in scores (very small effect). Switching between comma-separated and bulleted lists does not by itself have much of an impact on the participants' recall.

Unlike the main effects, the interaction between music type and format is statistically significant, p-value = 0.0417. This shows us that the effect of one factor depends on the level of the other factor. The combination of these two variables matters when observing recall time. An eta-squared value of 0.07 indicates that about 7% of the variation in recall scores is explained by pairing music type and the formatting of words. This interaction is significant, meaning that when looking at both variables at the same time, noticeable differences in recall performance are observed. Figure 4 shows the results of the ETA test conducted.

Parameter	Eta2 (partial)	95% CI
Music Type	0.02	[0.00, 1.00]
Format	8.80e-03	[0.00, 1.00]
Music Type: Format	0.07	[0.00, 1.00]

Figure 4. ETA test for measuring the effect size used in ANOVA

The set of bar charts shown in Figure 5 displays the effects of Music Type and Format when considered separately. Although there is a slight difference in mean scores under Instrumental music and Comma format, these results are not statistically significant. This visualization supports the results from the two-way ANOVA test conducted, which revealed that there is no significant effect of Music Type ( $F(2, 90) = 1.03$ ,  $p = .363$ ,  $\eta^2 = .02$ ) and no significant effect of Format ( $F(1, 90) = 0.80$ ,  $p = .374$ ,  $\eta^2 = .009$ ). These findings suggest that neither music nor formatting alone significantly influenced participant performance.



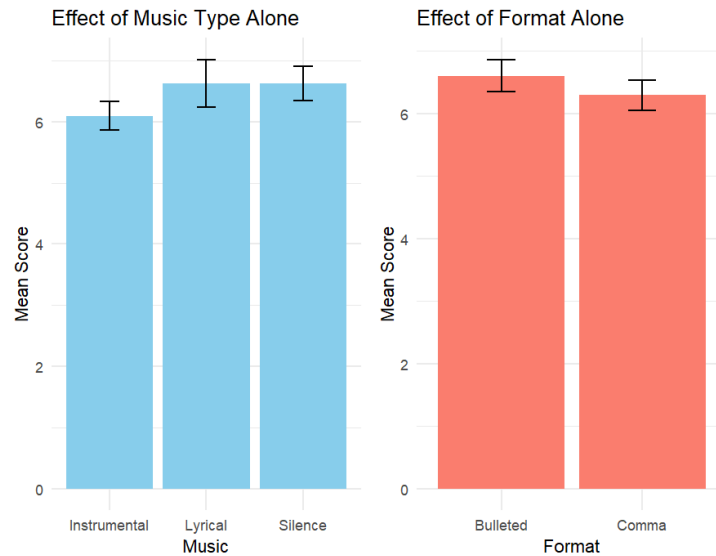


Figure 5. Bar Charts for Each Independent Variable

In contrast to the non-significant effects of Music Type and Format alone on performance, the interaction plot, shown in Figure 6, reveals that there is a statistically significant interaction between both factors, supporting the results from the ANOVA test conducted ( $F(2, 90) = 3.29, p = .042, \eta^2 = .07$ ). As represented in the graph, the crossing of lines indicates that the impact of formatting is contingent on the music type playing. Participants performed better on comma-separated lists when instrumental music was played, whereas participants scored higher on bulleted lists when lyrical music was played. Performance was relatively stable across both formats under silent conditions. This suggests that the combination of music type and format can either positively or negatively impact participant performance.

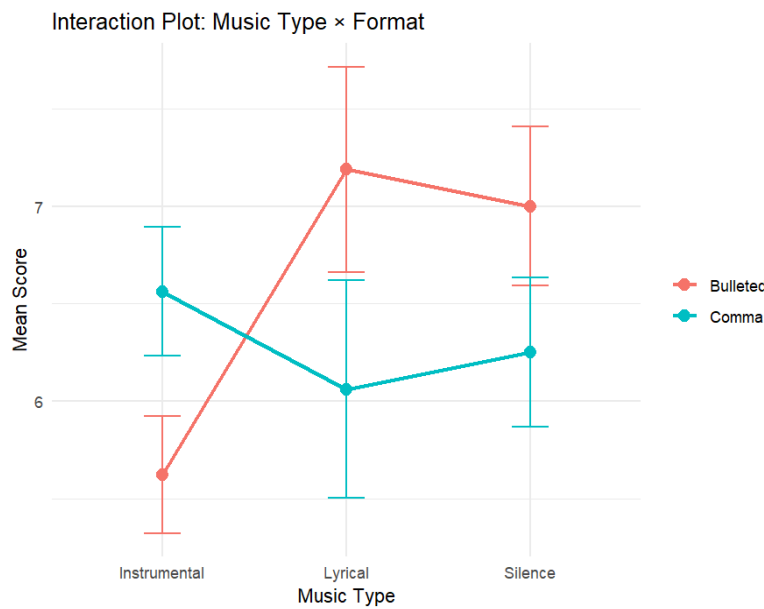


Figure 6. Interaction Plot between Music Type and Format

## 5.0 Discussion

The results of this study suggest that while neither background music type nor text formatting alone significantly influenced short-term memory recall, the interaction between the two variables was statistically significant. Specifically, the interaction between music type and text format ( $p = 0.0417$ ,  $\eta^2 = 0.07$ ) indicates that the influence of one variable depends on the other.

One plausible explanation for this interaction could simply be related to distraction and clarity. Participants might have found instrumental music less distracting, allowing them to comfortably read and recall comma-separated lists without difficulty. On the other hand, lyrical music could have introduced distractions from the lyrics, making the bulleted lists easier to follow and recall. Essentially, when the music was more demanding of their attention, participants benefited from a more straightforward visual layout. The performance in the silent condition for both the bullet point and paragraph format further support this interpretation. With no music, there wasn't any distraction around, so the type of text formatting had very little influence.

Considering these findings, future studies might investigate a broader range of music types as well as text formats to better understand the interaction between the two. Additionally, increasing the sample size and the diversity of the participants would help get clearer and better results. Moreover, getting some knowledge about the participant's study habits might offer a better understanding of how different people manage distraction during tasks that require the use of memory recall.

Overall, these findings offer useful guidance for educational and workplace environments, highlighting practical considerations such as selecting suitable background music and clear text formatting to enhance learning and information retention.

## References

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