

The Effect of Music on Short-Term Memory and Attention

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Abstract:- This study aims to investigate the effects of different genres of music on sustained attention and working memory. The study utilized a randomized controlled between-subject design while utilizing the non-probability sampling method of snowball sampling to collect participants for the study. The participants are 61 adults of various ages. They underwent two different tasks testing sustained attention and working memory while exposed to 3 different music conditions: Metal music, Pop music, and Silence. The researchers used Kruskal Wallis to analyze the data due to the data not being normally distributed. Results showed significant results for SART and the Digit Span Test (p values = 0.038 and 0.003). The significant interactions show that sustained attention was the most susceptible to distractions due to various genres of music, namely metal. Digit Span test also showed how silence had the least interference in working memory, with pop music having the most interference.

Keywords:- Music, Sustained Attention, Working Memory.

I. INTRODUCTION

A vital component of human culture, music is becoming more and more acknowledged for its potential benefits to cognitive performance, especially in terms of reducing the emotional toll of stress during high-processing jobs like academic writing. Nonetheless, there are many different aspects of music's impact on cognitive function, including individual variations, task type, tempo, genre, and personality attributes. Although studies indicate that music may improve cognitive function, they also point to certain drawbacks, with certain tasks being more vulnerable than others.

The purpose of this research is to carry out an experimental investigation into how the brain functions when exposed to various musical genres. Prior studies, like the one conducted by Geethanjali et al. (2016), have shown that listening to music causes physiological changes in individuals, which are accompanied by improvements in task performance. Even though there is proof that music affects performance, conclusions are still unclear. Contradictory data exists, such as the study by Lin et al. (2023), which indicated that slow music negatively affected cognitive processing speed. Studies like Cockerton et al. (1997) and Lehman et al. (2018) corroborate the positive effects of music on cognitive function.

➤ Sustained Attention

The capacity to concentrate on a task or stimuli for an extended length of time is known as sustained attention. Vigilance, or recognising the presence of stimuli, and concentration, or concentrating on the stimulus or activity, are the two main components of sustained attention. Sustained attention is one of the five components of Sohlberg & Mateer's (2001) Clinical Model of Attention, which is defined as the capacity to sustain attention over prolonged periods without experiencing appreciable performance variations. According to Jones et al. (2000), physical alterations in the auditory stream, such as sharp notes or abrupt shifts, may have an impact on sustained attention problems. However, as studies like Browne (2023) show a small decrease in sustained attention with background music compared to quiet, individual characteristics may modify how music impacts sustained attention.

Sustained attention dynamics are covered by several hypotheses, such as the Inverted U Hypothesis. According to this theory, there is a sweet spot for arousal or alertness that can be altered by outside stimuli like music and allows for sustained focus. Different musical genres and elements can influence physiological and emotional responses, which may have an impact on sustained attention. As a result, music can alter arousal levels.

➤ Short-Term Memory

Atkinson and Shiffrin defined short-term memory as the second stage of memory. It's a short-term storage system where the information that was acquired through physical or emotional stimuli is temporarily held for limited periods, where it can then be used for specific tasks or stored in long-term memory. George Miller also theorized that short-term memory is thought to be able to store up to seven different pieces of information at once.

Salame & Baddley (1988) showed that unattended vocal music and instrumental music, both had detrimental effects on short-term memory, with vocal music being more disruptive to short-term memory. This is also backed by Musliu et al. (2017) who found music with lyrics to reflect on short-term memory with negative performance when compared to a silence condition, where it also stated that relaxing music also had proved to have negative effects when compared to the silence condition.

➤ *Statement of Problem*

Due to the inconclusive studies in the field of music, short-term memory, and attention, this study will be undertaken to provide evidence of effects within them. It will find the comparative effects of their effects across different genres of music.

➤ *The Rationale of the Study*

The rationale of the study is to offer definitive results to the numerous inconclusive findings in the areas of music, short-term memory, and attention. Canesares et al. (2022), Cheah et al. (2022), and Dolegui et al. (2013) all found inadequate amounts of study on various musical genres and decisive conclusions in this area in their reviews of the literature. One of the study gaps in the subject has also been brought up concerning the lack of research on the impact of music on sustained and divided types of attention (Balogun, 2013). As proposed by Canesares et al. (2022), this study would also replicate the study in a new cultural context because it will be conducted in a largely Indian population. To determine the effects of emotional involvement on cognitive performance, the design of the study would also include a survey to determine the popular and unpopular musical genres that the population prefers (Lin et al., 2023; Kirk et al., 2022). The study fills in several research gaps since earlier studies did not take these particular themes into account, proving that its conclusions are consistent.

II. REVIEW OF LITERATURE

➤ *Detrimental Effects*

Research by Dolegui (2013) compared the effects of different music genres at varying intensities on cognitive task performance, finding that silence yielded better performance than music, particularly loud music. Cheah et al. (2022) conducted a systematic review showing that music, especially with lyrics, negatively affects memory-related tasks and reading comprehension, associated with sustained attention. Lin et al. (2023) similarly found slower music pieces to impair performance compared to silence, with high-arousal pieces also decreasing task performance. Goltz & Sadakata (2021) confirmed that music with lyrics, particularly pop and hip-hop genres, led to more distraction than instrumental music, impairing memory tasks while enhancing sustained attention. Lehmann et al. (2018) found music had no effect on short-term recall and sustained attention tasks, contradicting the findings of Chraif et al. (2013), who showed relaxation music negatively influenced short-term memory. Miskovic et al. (2008) discussed music's distracting effect on participants, reducing divided attention during complex tasks, while Chou & Tze (2010) demonstrated higher intensity music negatively impacted performance.

➤ *Beneficial Effects*

Instrumental music was found by Rashidi & Faham (2011) to boost sustained attention, as demonstrated by better reading comprehension scores. This was corroborated by Lin et al. (2023), who demonstrated that slow-paced music facilitated sustained attention tasks whereas fast-paced music improved processing speed and accuracy. Lyrical music was also found to significantly affect memory and sustained attention

tasks by Canesares et al. (2022) and Bottiroli et al. (2014), which is in line with Kirk et al.'s (2022) finding of a considerable improvement throughout their studies. Lehmann et al. (2018) found that participants performed better on transfer tasks when there was background music, which is consistent with Kiss & Kinnell's (2020) findings that background music reduced distractibility factors and boosted sustained attention. This was corroborated by Carryl et al. (2017), who discussed the attentional restoration hypothesis and suggested that music had a beneficial effect on sustained attention.

However, depending on variables including musical style, tempo, and individual personality qualities, music's impact on cognitive tasks varies. According to research, listener characteristics and music qualities can influence the effects of music on cognitive performance, which can be both positive and negative.

➤ *Individual Differences*

• *Impact of Lyrics*

Lyrical music as proven by Cheah et al. (2022) also considered an external factor, has a detrimental effect on cognitive performance, especially in the field of short-term memory and sustained attention. Lyrical music also proved to worsen performance than its instrumental counterpart in a study conducted by Goltz & Sadakata (2021), where pop and hip-hop were considered to be the worst genres of music to increase cognitive performance. They also proved that increased tempo provoked greater levels of cognitive impairments.

• *Personality Factors*

Cheah et al. (2022) found that whereas extroverts are less impacted by music with lyrics, introverts are more easily distracted by it. Silence greatly reduced the performance of extroverts. In contrast to quiet or unknown music, Kirk et al. (2022) discovered that listening to familiar music boosted sustained attention throughout challenging activities. Familiarity lessened distraction when doing mental exercises. According to Baldwin & Lewis (2017), musical taste had an impact on sustained attention, with enjoyable music leading to fewer missing responses.

• *Intensity of the Musical Pieces*

Dolegui (2013) found that intensity is a factor to be considered when comparing the effects of music. Their study proved that there was a significantly higher score in silence conditions when compared to conditions with high and low intensity. Lin et al. (2023) also found that higher tempo often increased accuracy while improving the processing speed of participants.

• *Task Complexity*

A study conducted by Kiss & Kinnell (2020) also revealed positive effects on task-focused attention in low-demand tasks, emphasizing the need for further research to understand the effects of task complexity. Learners also commonly demonstrate issues in understanding the tasks which overshadows the effect of music (Lehmann et al., 2018).

It is challenging to draw firm conclusions about the impact of music on the execution of cognitive tasks given the literature's complicated and frequently contrasting findings. The information that is now available, however, points to the possibility that music can have both beneficial and harmful effects and that these effects may differ depending on a variety of variables.

➤ *Research Gaps*

The majority of studies have only utilized popular music genres like classical or pop. But music comes in a wide range of genres, and each one can uniquely impact cognitive function. More study is required to determine how various musical genres affect cognitive function. Often, a variety of cognitive tasks were not taken and were limited to very few attention or logic-based tasks. There's also a research gap within the effects of tempo and loudness of music on cognitive performance. There also happens to be a lack of comprehensive research on how the impact of music affects cognitive performance across different age groups. Finally, there's a lack of comprehensive research taking into account individual factors other than extroversion, such as personality traits and cultural influences.

➤ *Research Question*

Does the music that participants listen to affect their short-term memory and sustained attention?

III. METHODOLOGY

➤ *Sample*

The population of the study would preferably be young adults, and a minimum of 15 participants per experimental group would be taken. The sampling method taken would be the non-probability sampling method of snowball sampling. No exclusion criteria are confirmed.

➤ *Operational Definitions*

The independent variable in the study is the music provided. It is manipulated as different genres are played to different experimental groups. The genres selected would be from the popular results of a survey that would be conducted. Music has been selected as the independent variable due to its malleability and flexibility in experimental conditions. It serves the purpose of detecting any changes in memory or attention processing when exposed to a particular type or genre of music.

The dependent variables are used to measure an individual's cognitive processing in memory and attention. Two dependent variables are going to be tested with the independent variables; short-term memory and sustained attention. Short-term memory has been taken as one of the dependent variables as it's a crucial part of one's cognitive process. Sustained attention as a dependent variable would allow us to gauge the effects that an external stimulus would have on sustained attention on particular tasks, it would allow us to gain an insight into the working of the cognitive processing that is involved in attention.

➤ *Hypothesis*

- Ha1: Errors made in the short-term memory tasks will be significantly higher in the group with unpopular music, average with popular music, and low in the control group.
- Ha2: Errors made in the sustained attention tasks will be significantly higher in the group with unpopular music, average with popular music, and low in the control group..

➤ *Research Design*

A randomised controlled between-subjects experimental design will be used in this investigation. This design compares group differences after participants are allocated to various experimental settings. While control groups receive no treatment, each group is given a treatment involving an independent variable. A comparison of the dependent variables between groups will be used to determine how effective the manipulation was. To lower the possibility of bias, masking will be used to keep participants from finding out which group they are assigned to. Additionally, this approach streamlines data collection and reduces carryover effects.

The assignment of the three groups would be random in nature. A random number generator would be used to decide which participant would be assigned to the particular experimental group. Group 1 would listen to the popular genre of music and Group 2 would listen to the unpopular genre of music, which would be chosen by the results of the previously conducted survey. They would perform memory and attention tasks while listening to the popular genre of music. They would perform memory and attention tasks while listening to an unpopular genre of music. Finally, Group 3 would be the control group. These participants would complete the memory and attention tasks assigned in silence. After this, the data would be analyzed through statistical tools like ANOVA or Kruskal-Wallis to get the final results of the study.

➤ *Tools Used*

The following tests are taken from PsyToolkit which is a free and open-source software for designing and running psychological experiments online. It's easily accessible and is well-documented. A study by Kim et al. (2019) has also shown its results to be comparable to E-Prime, a commercial experimental software package. PsyToolkit has also been used in a variety of studies such as neuropsychological functioning and language learning (Sjöwall & Thorell, 2014; Smalle et al., 2017). PsyToolkit also has good test-retest reliability and validity.

• *Digit Span Test:*

The immediate memory test, also known as the digit span test, starts with two letters and increases with the progression of the test. The participant is presented with the sequence of digits, slowly appearing one digit at a time. The participant is required to reproduce the sequence of numbers presented. There are two sets of numbers provided with each level of the test. If the participant can repeat the sequence twice, the longer sequence is then presented. The longest remembered sequence, where the participant has remembered the same length twice, is the participant's digit span. This variation of the digit

span presented in PsyToolkit, makes this measure more reliable. The tests can maximally measure nine digits, as the tenth digit will always be known. The test stops when the participant makes two mistakes in a row or if they have reached the maximum of nine digits.

- *Sustained Attention to Response Task (SART):*

It is a computer-based test that measures sustained attention. The test is designed to be challenging and requires the participant to focus on a single task for an extended period. The time duration of this test would be five minutes. The participant would be presented with a digit, which is present for 250ms followed by a mask for 900ms. Participants are asked to press the spacebar after every digit presented to them, except for the digit 3. The digits never repeat each other and are represented in rapid sequences. The target digit appears infrequently, for which participants must sustain their attention to inhibit their response to the non-target digits. The SART is scored in terms of the number of correct responses and the number of errors. The SART is a well-validated and reliable test which is widely known for sustained attention and inhibitory control.

- *Google Form Survey:*

A survey will be created and circulated that contains questions that would help the researcher gain insight into the more popular and unpopular genres of music. It would allow the researcher to understand the consensus of the public opinions about various kinds and genres of music.

- *Procedure*

Most and least popular music genres will be determined by a survey one month before data collection. Three groups will be randomly selected: Group 1 will play popular music, Group 2 will play unpopular music, and Group 3 will play quiet as a control. Short-term memory and sustained attention will all be measured using memory and attention tests. The results of the survey, which also indicate popular streaming sites, will be used to select music.

Using an online tool like PsyToolkit, users and researchers will collaborate to complete tasks during trials. These tasks include the sustained attention to response test for sustained attention and the sequence recall Digit Span test. The results of the study will be obtained by data analysis using ANOVA and other statistical method.

- *Data Analysis*

Descriptive statistics would be used to provide insight into how different groups can be compared. It would be essential in summarizing the data, allowing us to identify any patterns or trends within the data. It can also be used to identify any outliers that may present itself within the data.

The Shapiro-Wilk test would be used to determine if the data is normally distributed. A normal distribution is in the form of a bell-shaped curve that is symmetrical around the mean. If the data is normally distributed, the Shapiro-Wilk test will not be significant. If the data is not normally distributed, then the Shapiro-Wilk test will be significant.

If the data is normally distributed, ANOVA would be used to compare the means of the three groups. Since the study is comparative, ANOVA can be used to analyze the data in the study. ANOVA measures variance by contrasting it with variance within groups. The genre of music that participants listen to affects their short-term memory, sustained attention, and divided attention if the ANOVA results reveal a significant difference between the means of the three groups.

If the data is not normally distributed, then the Kruskal-Wallis test would be used instead of ANOVA. The Kruskal-Wallis test is a non-parametric statistical test that is used to compare the medians of three or more groups. It is a non-parametric test, which means that it does not make any assumptions about the distribution of the data. This makes it a more robust test than ANOVA, which can be sensitive to violations of the assumption of normality. The Kruskal-Wallis test would be used to compare the medians of the cognitive performance scores of the three groups: Group 1 (popular music), Group 2 (unpopular music), and Group 3 (silence). If the results of the Kruskal-Wallis test are significant, then it would mean that there is a difference in the medians of the three groups. However, the Kruskal-Wallis test does not tell us which groups are different.

IV. RESULTS

Table 1 Descriptive Statistics

	Condition	Mean	SD	Shapiro-Wilk	
				W	p
Digit Span	Metal	5.9000	1.3338	0.878	0.016
	Pop	5.6842	1.2043	0.934	0.203
	Silence	6.6364	1.0931	0.921	0.078
SART (error rate)	Metal	0.1148	0.0436	0.979	0.922
	Pop	0.0650	0.0392	0.933	0.193
	Silence	0.0879	0.0528	0.939	0.193

➤ *Based on the Provided Information:*

Shapiro-Wilk p-values for Digit Span are less than 0.05 for every instance, meaning that there is a significant deviation of the data from a normal distribution. The data may follow a normal distribution for the SART error rate if the Metal and Pop conditions have Shapiro-Wilk p-values more than 0.05. In contrast, the Silence condition has a p-value less than 0.05, indicating non-normality. Every condition has a Shapiro-Wilk

p-value for the Stroop error rate that is less than 0.05, suggesting non-normality.

These findings imply that the normality assumption needed for parametric tests may not hold for every variable; for this reason, non-parametric tests such as Kruskal-Wallis are used when comparing groups.

Table 2 Kruskal Wallis Significance Results

	χ^2	df	p	ϵ^2
Digit Span	6.54	2	0.038	0.109
SART (error rate)	11.89	2	0.003	0.198

- Note: M – Metal, P – Pop, S – Silence

The Kruskal-Wallis test statistic for the Digit Span test is $\chi^2 = 6.543$, with 2 degrees of freedom, and a p-value of 0.038. This suggests that there is a significant difference among the groups in terms of Digit Span performance. The effect size (ϵ^2) is 0.10904, indicating a moderate effect. As for SART, the

Kruskal-Wallis test statistic is $\chi^2 = 11.886$, with 2 degrees of freedom, and a p-value of 0.003. This indicates a significant difference among the groups regarding the SART error rate. The effect size (ϵ^2) is 0.19811, indicating a relatively large effect.

In summary, there are significant differences among the groups for Digit Span and SART (error rate).

Table 3 Pairwise Comparisons - Digit Span

		W	p
Metal	Pop	-0.887	0.805
Metal	Silence	2.413	0.203
Pop	Silence	3.568	0.031

Participants did somewhat worse when listening to Pop music than when listening to Metal, however, the difference was not statistically significant ($p = 0.805$). Participants also did not significantly perform better when listening to silence

music than when listening to metal ($p = 0.203$). Whereas when comparing Pop and Silence, participants' performance was significantly better when listening to silent music ($p = 0.031$) than when listening to pop music.

Table 4 Pairwise Comparisons - SART (error rate)

		W	p
Metal	Pop	-4.89	0.002
Metal	Silence	-2.90	0.100
Pop	Silence	1.93	0.362

Participants made significantly more errors in the Metal condition compared to the Pop condition, with a mean difference of -4.89 ($p = 0.002$). While participants made fewer errors in the Silence condition compared to the Metal condition, the difference was not statistically significant, with a mean difference of -2.90 ($p = 0.100$). When comparing Pop and Silence conditions, there was no significant difference in error rates between the conditions, with a mean difference of 1.93 ($p = 0.362$).

found that they had different impacts on different cognitive tasks. The interference was highest in SART, the tool used to measure sustained attention, along with the Digit Span test, which measured working memory.

V. DISCUSSION

The purpose of the experiment is to provide evidence of how different genres of music affect cognitive abilities such as working memory and sustained attention. The study positively contributes to the body of knowledge specifically on the significant effect of metal and pop genres of music on sustained attention and working memory. Despite exposing the participants to the same experimental conditions and tasks under pop and metal genres of music along with the control group, it was

When it came to interference from different musical genres, sustained attention had the greatest effect; a p-value of 0.038 indicated substantial significance. Smilek, et al. (2010) conducted a study that provides strong evidence for the validity of SART in measuring attention-related errors. The study found that SART is an amazing tool for measuring attention-related measures, particularly when it comes to its relationships with other measures and its neutral correlates. According to certain research, such as that done by Browne (2023), listening to background music slightly impairs sustained attention compared to listening to music. According to Jones et al. (2000), the degree of physical modification within the auditory stream can be regarded as a fundamental factor in a disruption of sustained attention. The preservation of prolonged attention

can also be significantly impacted by harsh remarks and adjustments. This is particularly evident in the way that SART is impacted by metal music in comparison to the other experimental conditions. The outcome also goes against the findings of a study by Lehmann et al. (2018), which found no relationship between music and cognitive tasks including sustained attention or short-term memory.

According to Cheah et al. (2022) and Lin et al. (2023), working memory was considerably hampered by various musical genres. Pop music interfered the most, whereas the control group did the best. This supports the findings of Goltz & Sadakata (2021) that fast-paced genres like hip-hop and pop cause higher levels of impairment when performing cognitive tasks. This study contradicts the findings of Lehmann et al. (2018), who reported no effect on cognitive tasks. Contrary to the results of this study, which indicated that silence was preferable, Canesares et al. (2022) discovered that lyrical music enhanced working memory.

VI. LIMITATION

The genres of music chosen by the results of the survey may not be an accurate representation of the music community as a whole. The smaller sample size may skew the results in the genres of music chosen in the survey, due to external factors such as culture and environment. There also might be other confounding factors that can externally affect the results of the study such as external stress, fatigue etc. There is also another possible issue that the length of the music chosen might not be long enough to determine a significant effect on the individual and their performance on the divided attention task. The results of the study also may not be generalizable to other tasks or settings.

➤ Ethical Considerations

Informed consent should be taken from the participants after a debriefing is presented. Researchers should ensure that the participants have an understanding of the study's aims, procedures, and potential risks. The data would be kept confidential and private. Participants reserve the right to withdraw at any time during the experiment. No harm shall be done to the participants of the study. There should be no discrimination or bias towards participants during the research process or in the way the participants are treated. Researchers must also take all reasonable steps to minimize the potential for harm to the participants. The researchers will also be more transparent with their research methods and findings.

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