

Music Influence on Cognitive Function among University Student: An Experimental Study Through a Randomized Controlled Trial

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Abstract

Engaging with music while studying can influence academic performance among students. Several studies have shown a negative effect of non-classical genres on short-term memory performance yet still limited to classical background music, especially in the context of Malaysian culture. Therefore, a present study investigated the impact of classical background music on short-term memory performance among undergraduate female participants ($N=48$) from Sultan Idris Education University (UPSI). The study employed a Randomised Controlled Trial (RCT) design where purposive sampling with inclusion and exclusion criteria was used to recruit the participants, which then randomly assigned into four groups: Solo piano, Orchestral, Operatic, and No music through single-blind method. The short-term memory task consisted of 20 trials of 5-letter nonsense syllables displayed for three seconds, with an 8-second gap between each trial and the scoring ranged from zero to 20. Classical music from the romantic period was selected, featuring five different short pieces looped in each condition. The results of one-way ANOVA and Tukey (HSD) post hoc analysis showed significant mean differences among the groups ($F(3, 44) = 15.95, p < .001$) with the Operatic group exhibiting the lowest accuracy in short-term memory compared to the other groups ($M_{diff} = 5.33, p < .001, M_{diff} = 3.16, p = .002, M_{diff} = -4.08, p < .001, \alpha = .05, SE = .57$). Future researchers should address the following improvements: larger and diverse sample size to avoid bias assumptions, suitable experimental design for task variety and cultural acceptance of background music, and alternative psychology analysis methods.

Keywords Short term memory performance, cognitive function, classical background music, auditory cue, Randomised Controlled Trial

INTRODUCTION

The extent of an individual's capability to store and retrieve information is simply phenomenal (Brady et al., 2009). Previous researchers collectively agree that the brain has its own hierarchical structure of how it gathers the input, regulates the process and output (Neisser, 1967). However, students often experience significant frustration (Vogel & Schwabe, 2016) when they find themselves unable to remember what they had learned the previous day, struggling to recall information from exams or lectures, and encountering difficulty in retaining crucial details such as datelines.

Short-term memory can be defined as the temporary storage of information that was available for processing during a short period of time (Vallar, 2002). According to Queensland Brain Institute Australia (n.d), the ability to retain new information is found to be most efficient in individuals who are in their 20's. Additionally, a survey conducted from online university CSU Global (Steinberg, 2022) that 58% of Gen Z students that were associated with listening to music tended to receive a higher GPA as 60% of them are comfortable engaging with music in the background while studying, 36% agreed

that classical music tended to help them study as opposed to other types of music and 58% from the survey agreed that students should allow themselves to experience learning while listening to music..

The term background music can be described as a type of music categorised as an audio accompaniment (Gärtner & Dittmar, 2009) or an external condition stimulus that could influence people's cognitive processes (Threadgold et al., 2019) depending on the type of music they engaged with (Cockerton et al., 1997; Hallman et al., 2002). Previous studies have delved into the impact of background music, spanning various from non-classical, on short-term memory. There are a few factors that could interfere from storing the memory such as the limits of the attention given in the sense of cognitive load and auditory distraction (Maranges et al., 2017). Georgi et al. (2022) and Meinhardt-Injac et al. (2022) noted that multiple music led to a noticeable decrease in serial recall, emphasising the role of music conditions in memory tasks. Specifically, conditions involving speech background were found to limit attention span and the successful completion of verbal short-term memory tasks.

On the other hand, Silverman & Schwartzberg (2018) discovered that accuracy was higher when the background music was melody-based, causing less distraction and facilitating better recall of digits. Opheij (2021) highlighted that maintaining the same background music with a short gap for recall improved cognitive task performance. In contrast, Park et al. (2020) argued that background music does not negatively impact attention span; instead, it aids individuals and mostly does not impede the ability to perform cognitive tasks, especially instrumental music. Kiss & Linnell (2023) suggested that appropriate background music, contextualised correctly, could enhance students' performance and reduce poor attentional control. They also noted that some students use background music as a tool to aid focus in tasks, particularly those involving memorization.

As technology dominates daily life today, the advent of a technology-driven lifestyle raises concerns about the impact on attention spans, often influenced by the prevalence of multitasking. Existing research uniformly cautions against indiscriminate multitasking, highlighting the brain's limitations in managing either several simultaneous complex tasks or processing identical task demands simultaneously (Dzubak, 2008; Feng et al., 2014). Lehmann & Seufert (2017) contribute to this narrative by proposing that tasks characterised by short time spans for recall or other cognitive functions may not necessarily demand significant effort to process information or divert attention. Learners who have already reached a saturation point in cognitive load for specific learning material might find these tasks less taxing. Furthermore, Canesares et al. (2022) add a layer of nuance by suggesting that not every heavy auditory material would exert a significant effect on specific cognitive tasks, especially if individuals are familiar with the music they prefer to listen to.

However, the lack of extensive research on classical background music has made it challenging to say the same between the information processing associated with auditory stimuli and short-term memory performance. Nevertheless, some researchers infer that classical music allows the brain to enhance and store new information (Sridharan et al., 2019). Bottiroli et al. (2014) also agree that classical music can help people to gain and store new information as their study result showed a positive number of people who are able to memorise and perform better to other related cognitive tasks. Still, it is unknown to say the least that classical music can overall make a less impact on short term memory performance. With the mixed findings from previous researchers across the world, the objective of this research is to investigate the effect of classical background music toward students' short-term memory performance in Sultan Idris Education University.

METHODOLOGY

Research Design

This study conducted experimental design using a Randomised Controlled Trial (RCT) design (Vine et al., 2014) with a single blind method (Karanicolas et al., 2010) which consisted only one independent variable: background music, and the dependent variable was the short-term memory performance through adaptation from Ebbinghaus' nonsense syllable approach (Ebbinghaus, 2013b; Linton, 1982) combined with Tulving & Watkins (1973) and Wallace et al. (1968) designs. With a single blind method approach, the students were randomly placed through a random allocation process (Kim & Shin, 2014)

into two groups: the experimental group and the control group through a random allocation process. Additionally, in the experimental group, there were three subgroups derived from independent variables: Solo piano, Orchestral, and Operatic background music. Meanwhile, the control group did not receive any background music (no music).

Instruments or Materials

Background music

The researcher used *Wiresto* Wireless Headphones as it had noise cancelling features that gave participants a full experience while using it, allowing them to concentrate on the music without being distracted by their surroundings to receive the optimum results and distinctive impact in each experimental group. Additionally, the volume of the background music was configured through Sound Meter apps and set to 85 decibels (dB) or 70% for the experimental groups (World Health Organization, 2015). Moreover, the researcher selected compositions from the classical period for each condition with background music in this experiment. There were three sets of classical pieces in the romantic period genre that were specifically designed for each type of the group. The total duration of the background music was 10 minutes across all groups.

Short term memory task

A total of 20 sets of nonsense syllable letters were created in Canva and presented in Microsoft PowerPoint with the visual display consisting of a white background featuring bold *Times New Roman* font, set at a size of 360 for both the experimental and control groups. In addition, *Acer Swift 3* and a screen projector was used to display the visual material, which also remained consistent across all groups involved. All the same 20 letters of the nonsense syllable remained constant with the same duration (5 minutes 50 seconds, including other duration such as given the instruction and a few seconds for the participants to be prepared).

Procedures

A controlled experiment was held at Experimental lab room 4 for every group in this study with the dimmest level of light (during the experiment). The room consisted of a screen projector and comfortable chair, as well as a few tables available to use. Participants were invited to voluntarily join a study about the short-term memory performance test. A brief explanation was given to the participants, and all the information was explained as the researcher obtained participants' consent. After they sat comfortably four metres from the screen projector, informed consent was obtained from each participant. The researcher would repeat the instruction again if needed to ensure all the participants understood the task they needed to perform. In addition, the instruction was visually presented on the screen projector. For the experimental group, the instruction was given as follows:

“Have a seat and relax on the chair. During the experiment, you will not be subjected to any sort of jump scare in any form. You will need to wear this headphone until the end of this experiment. In the next section, a red circle will appear on the screen. When the red light blinks, you need to be ready as the trial is about to begin. As the green light appears, some letters will appear for a few seconds and disappear afterward. The red circle will be blinking again, and you must wait until the green circle icon appears and then verbally recall the letters immediately. This will be repeated until the experiment is finished.”

Following the explanation, the participants were administered a trial session using the same instructions as provided earlier. Specifically, participants in the experimental group were informed that background music would be utilised to enhance their comfort during the task. Moreover, the background music will be played a few seconds before the nonsense syllable letters are displayed for four seconds, with a eight seconds gap between each subsequent letter. The task that was selected in this experiment consisted of 20 sets of 5-letters nonsense syllables with non-repeating consonant letters (e.g., KGFTD). Figure 3.2, adapted from Geurten et al. (2016), provided an illustrative representation of the experimental procedure.

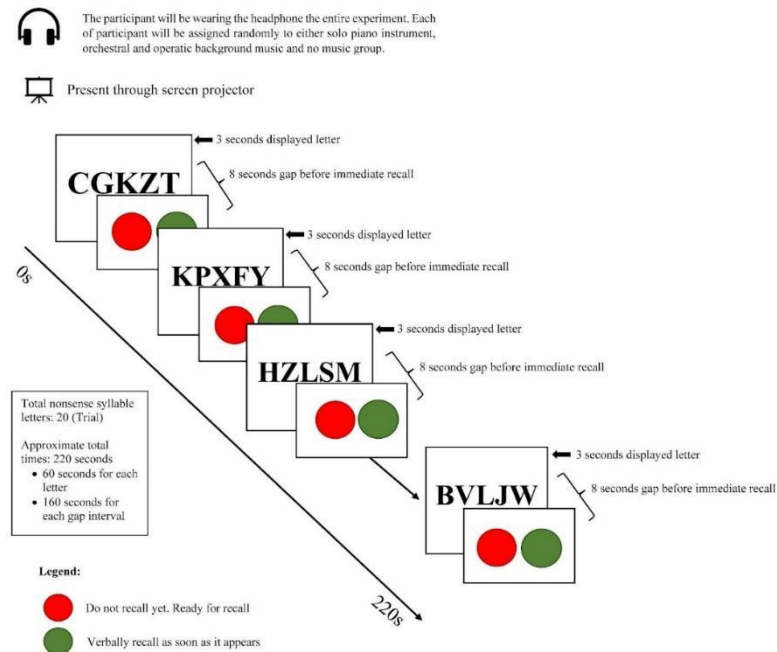


Figure 3.2 The Illustration of the Procedure for the Current Study. Adapted from Geurten et al.

As for the control group, all the procedures will be the same – instead of instructed to wear headphones for listening to the background music, the researcher will explain the use of headphones is to cancel the external noise throughout the experiment. Upon completion of both experiments in the Experimental and Control groups, the participants were provided with a debriefing by the researcher regarding the actual purpose of the study. The result, then was explained to the involved participant as they requested it. To express appreciation for their participation, all participants were presented with a small token of gratitude.

Participants

A total of 48 undergraduate female students ($N=48$) from Sultan Idris Education University (UPSI) were obtained through purposive sampling with inclusion and exclusion criteria which were the age of participants ranging from 19 to 25 years old, female undergraduate students from first until semester 5 that were located in KSAS Campus. Furthermore, the recruitment was created through Google Form and it was distributed through various social media platforms such as *WhatsApp*, *Gmail*, *Telegram*, *Instagram* and *Facebook*.

Pilot test

Prior to the actual study, two pilot studies were conducted using Ebbinghaus' original nonsense syllable approach in which, 20 sets of nonsense syllable letters with each trial used the CVC and CCC trigram method which consists of two consonants and one vowel (for example, GEX) and consonant letters (For example, FJG).-The findings from the first pilot study revealed the presence of a ceiling effect in the design, as indicated by the absence of variability across all the groups. A second pilot study was conducted to refine the task design and increase the level of difficulty with several improvisations were made to enhance the task parameters, specifically the number of nonsense syllable letters and the gap interval of between them. The analysis of the second pilot study revealed that among the various combinations tested, it was observed that the 5-letter nonsense syllables with a 3-second display duration demonstrated the optimal level of variability in the accuracy of short term memory performance.

RESULT

Table 3.1 Descriptive Statistics from the Current Study.

Condition	Mean (M)	Standard Deviation (SD)
Experimental Group		
Solo piano	17.42	1.78
Orchestral	15.25	2.01
Operatic	12.08	1.98
Control Group		
No music	16.17	2.12

* The descriptive statistics below provide a full summary of the central tendency and variability of the data for each group that was obtained from this study.

From the dataset above, it shows that the Solo piano group had the highest mean score ($M = 17.42$, $SD = 1.78$), followed by the No music group ($M = 16.17$, $SD = 2.12$), the Orchestral group ($M = 15.25$, $SD = 2.01$), and the Operatic group ($M = 12.08$, $SD = 1.98$). These results suggest that the Solo piano group had the highest average score while the Operatic group had the lowest average score from the other conditions. A graphical representation from the data is shown in Figure 3.1

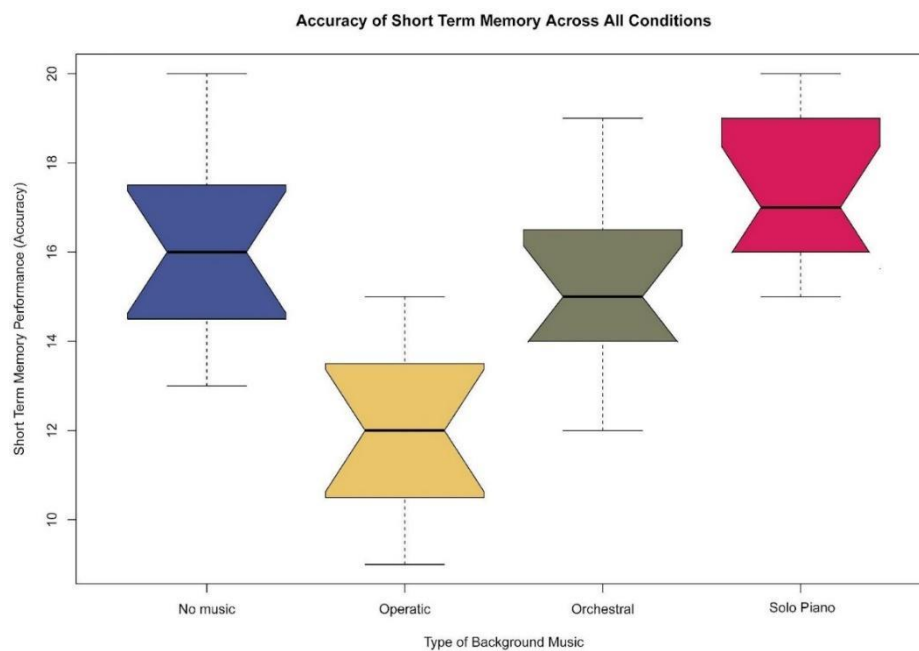


Figure 3.1 Boxplot Graph of the Descriptive Statistic

Based on Figure 3.1, the y-axis of the graph represents the accuracy from short term memory performance tasks, while the x-axis represents the different types of background music groups being compared. According to the boxplot, the standard deviations indicate that the data for each group had different degrees of variability around their respective means. In terms of skewness, the values indicated variations in the distribution of accuracy across the groups. The No music group exhibited a slight positive skewness (.27), while the Operatic group showed a skewness of .09, suggesting a less skewed distribution. The Orchestral group displayed a skewness of .31, and the Solo piano group exhibited a similar slight positive skewness (.13).

Table 3.3 One-way ANOVA Result from the Current Study.

Sources of Variation	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>p</i>
Between Group	186.7	3	62.24	15.95*	<.001
Within Group	171.8	44	3.90		
Total	358.5	47			

* $p < .05$

Assuming the homogeneity of variance were normal in this study, the results from one-way ANOVA revealed that one or more classical background music groups had a significant effect on accuracy of short term memory performance tasks ($F(3, 44) = 15.95, p < .001$), with a large effect size ($\eta^2 = .52$). Specifically, the mean from the Operatic condition indicated the lowest accuracy scores, while the Solo piano condition produced the highest accuracy scores. Hence, the null hypothesis was rejected. Moreover, these findings suggest that the background music is an important factor to consider when designing tasks that require short term memory performance.

Table 3.4 Post Hoc Analysis by using Tukey (HSD).

Comparison	M_{diff}	<i>SE</i>	p_{adj}	95% CI	
				Lower bound	Upper bound
Operatic-No music	-4.08	.57	<.001*	-6.24	-1.93
Orchestral-No music	-.92	.57	.67	-3.07	1.24
Solo-No music	1.25	.57	.42	-.90	3.40
Orchestral-Operatic	3.17	.57	.002*	1.01	5.32
Solo-Operatic	5.33	.57	<.001*	3.18	7.49
Solo-Orchestral	2.17	.57	.05	.01	4.32

* $p_{adj} < .05$, *CI* = Confidence Interval, M_{diff} = Mean Differences, *SE* = Standard Error.

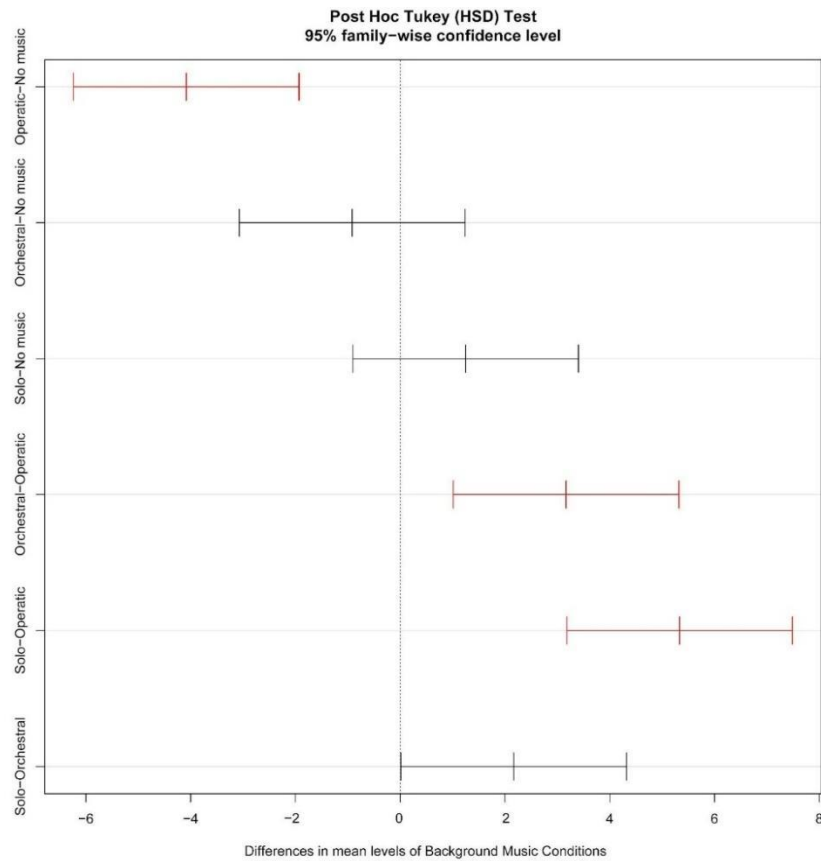


Figure 3.2 Tukey (HSD) plot of Post Hoc Analysis

Based on Table 3.4 and Figure 3.2, the results of the Tukey HSD test revealed significant differences in participant who in were placed in Solo piano, Orchestral and No music when compared to Operatic group ($M_{diff} = 5.33$, $p < .001$, $M_{diff} = 3.16$, $p = .002$, $M_{diff} = -4.08$, $p < .001$, $\alpha = .05$, $SE = .57$, respectively). However, there are no significant differences in participants who were placed in No Music when compared to the Solo piano and Orchestral group ($M_{diff} = 1.25$, $p = .42$, $M_{diff} = -.92$, $p = .67$, $\alpha = .05$, $SE = .57$, respectively). Moreover, there are also no significant differences in the pairwise group of Solo Piano and Orchestral group ($M_{diff} = 2.17$, $p = .05$, $\alpha = .05$, $SE = .57$). Overall, these results suggest that different types of music can have an impact on short term memory performance scores. Specifically, classical background music with lyrical accompaniment (Operatic) gave detrimental effects to students compared with other non-lyrical classical background music (Solo piano, Orchestral) or no background music.

All things considered, the analysis revealed a large effect size according to Cohen (1988) and Miles & Shevlin (2001) standard, with eta squared estimated at $\eta^2 = .52$. These results suggest that the study possessed sufficient statistical power to support the conclusion that the type of background music significantly influenced participants' accuracy in the short-term memory performance task.

DISCUSSION

Generally, from the findings, it suggested that different types of classical music had a differential effect on the accuracy of short-term memory performance tasks. From Meinhardt-Injact et al. (2022) and Georgi et al. (2022) studies, the current study is still aligned with their findings as any sound that associates with speech or lyrical based music, tends to reduce the level of accuracy when performing the short-term memory task. This can be proven as the operatic classical music genre had a noticeable effect on short-term memory performance. Hence, this result also aligned with Opheij (2021) indicate

that the specific genre of classical music plays a crucial role in determining its impact on short-term memory tasks, specifically that lyrical classical music yielded lower accuracy compared melody-based classical background music (Meinhardt-Injac et al., 2022; Georgi et al., 2022; Silverman & Schwartzberg, 2018).

Gap interval wise, it still had varying effects across all the conditions of the classical background music. These findings suggest that auditory cues and cognitive load significantly contribute to the storage of memory as Maranges et al. (2017) stated in their study that demanding nature of cognitive tasks, mixed with auditory distractions, can influence the accuracy of short-term memory performance. Although, as the level of demanding from cognitive tasks and auditory distraction did not make an account in this study directly, these conditions might have the limit on what information can be processed and stored according to Suthers (1996) theory. If the assumption is true, the encoding and retrieving process might be delayed resulting in low accuracy due to the lack of information that can be gathered (Goldstein, 2014).

Several previous researchers have noted that the accuracy of cognitive performance can be influenced by the level of concentration and attention, which may be hindered by the presence of background music. However, the current study does not align with the findings of Park et al. (2020), as lyrical classical music had the most pronounced effect, resulting in the lowest scores in cognitive performance. Therefore, these results emphasise the importance of considering the specific characteristics of background music in relation to attention and cognitive performance.

This current study does not find support from Canesares et al. (2022) as packed musical elements as operatic-based classical background music can have a detrimental effect on cognitive tasks and it impedes the primary goal of achieving accurate scores by diverting attention away from the task at hand. Hence, its support Dzubak (2008) and Feng et al. (2014) studies, as they highlighted the adverse effects of such music on multitasking abilities when simultaneous processing of auditory input and cognitive load can exceed the individual's capacity, resulting in decreased accuracy when performing the cognitive task itself.

Regarding the nature of the task, Kiss & Linell (2023) have argued that engaging in complex cognitive tasks diminishes the ability to achieve high scores in recall tasks. Although the current study did not involve a complex task, the inclusion of lyrical classical background music provided ample evidence of its impact on even simple tasks. Nevertheless, the present study findings corroborate the assertions made by Lehman and Seufert (2017), suggesting that although students may not possess prior exposure or familiarity with classical music, they are still able to concentrate and achieve satisfactory performance, regardless in the presence of unfamiliar auditory stimuli except when exposed to operatic music.

The study faces limitations in population and sample representation, experimental design, and analytical methods. The gender imbalance in participant selection and potential discomfort due to the researcher's gender may impact generalizability. The focus on a single short-term memory task limits the exploration of cognitive abilities. Cultural mismatch with the background music may influence responses. The analysis relies solely on one statistical method, potentially overlooking nuances. To address limitations, future research should diversify participant samples by collaborating with multiple institutions. Striving for gender balance is crucial. Experimental design should include a wider range of tasks to avoid bias, and music choices should align with participants' cultural backgrounds. Comprehensive analytical approaches, including non-invasive methods (EEG, fMRI), psychometric measures, and biofeedback, should be integrated for a nuanced understanding of background music's effects on cognitive performance.

CONCLUSION

The study highlights the profound influence of background music on students' cognitive performance. Favouring non-complex music, especially solo piano compositions, is recommended for creating an environment that enhances concentration and memory encoding. Conversely, caution is advised against lyrical-based classical music, particularly operatic compositions, which may act as distractions hindering cognitive tasks. Individual familiarity with music and its complexity are emphasized as influential factors in cognitive outcomes. The study also advocates for a personalized approach, aligning music choices with task complexity for optimal cognitive results. Additionally, it contributes significantly to cognitive psychology by unravelling the interplay between auditory stimuli and cognitive load, providing insights into short-term memory tasks. Last but not least, the findings enhance our understanding on human brain functionality that aligned with the information processing model (Lutz & Huitt, 2003), emphasizing the need to manage resources effectively in the presence of potentially distracting background music.

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