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The Impact of Musical Components on Retrieval Performance

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THE IMPACT OF MUSICAL COMPONENTS ON RECALL PERFORMANCE

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Many students claim that they can study well while listening to music (Anderson & Fuller, 2010; Patton, Stinard, & Routh, 1983), but how does listening to music affect students' ability to encode and recall studied information? Previous research on background music and attention has revealed mixed results, with some studies indicating that background music can help reduce inattentional blindness (Beanland, Allen, & Pammer, 2011), while others suggest that music may hinder the attention of the listener (by Shih, Huang, & Chaing, 2012). Additionally, individual differences in working memory capacity impact one's ability to store and retrieve information, as well as to suppress any intrusive thoughts and ignore distractions (Cowan et al., 2005; Rosen & Engle, 1998). The purpose of the present study was to determine if the musical components of polyphony and homophony impact students' ability to encode and recall information, while accounting for the impact of working memory capacity. Participants were randomly assigned to one of five musical conditions: simplistic without lyrics, simplistic with lyrics, complex without lyrics, complex with lyrics, or control (silence). In each condition, participants studied Swahili English word pairs, then completed a verbatim recall test. Higher working memory capacity was associated with recalling more items correctly. The results of the study indicated that there were no significant differences in recall performance due to music condition when accounting for working memory capacity. Potential explanations for the results of this study, as well as implications for future research, are examined.

Introduction

Many students claim that they can effectively study while listening to music (Anderson & Fuller, 2010; Patton, Stinard, & Routh, 1983), leaving many to wonder whether doing so impedes students' ability to encode information. Many studies have investigated the broad effect of background music on controlled attention (Cauchard, Cane, & Wegner, 2011; Beanland, Allen, & Pammer, 2011); however, little is known about the effects of specific musical components on encoding and recall during academic tasks. Additionally, individual differences in cognitive factors known to impact academic performance, such as working memory (Conway & Engle, 1994; Rosen & Engle, 1998), may influence students' ability to recall information while listening to music. The purpose of the present study was to examine whether certain musical components, such as polyphony and homophony, influence students' ability to encode and recall semantic information, while accounting for the known impact of working memory on recall performance.

Defining Music Technicality

Polyphony and homophony are identifiers of music technicality: polyphony refers to musical complexity, and homophony is the term for musical simplicity. Polyphony is characterized by fast-paced music with various time signatures, multiplicity of sounds, individual and/or harmonizing parts, complex rhythmic and melodic components, as well as various keys, tones, and melodies (Guralnik, 1984). Homophony, on the other hand, is characterized by few changes in tone, few changes in key, slow-paced rhythms, melodies carried in unison, similar pitch, and consistent time signatures (Guralnik, 1984). Previous research indicates that processing or focusing on unnecessary elements of to-be-learned information (e.g., superfluous text that needlessly explains diagrams or redundant information) contributes to extraneous cognitive load (Sweller, 2011). If students choose to listen to music while studying, music technicality may be one such element and ultimately could be detrimental to students' ability to encode semantic information.

The Role of Working Memory Capacity in Retrieval

Ashcraft and Radvansky (2010) define encoding as "the act of taking in information and converting it to a usable mental form" (p. 39). When a student is studying for a test, they are attempting to transfer information from working memory to long-term memory. According to Cowan et al. (2005), working memory is the set of mental processes that allows for the storage of small amounts of information that are active and can be used while engaging in ongoing cognitive tasks. Working memory capacity impacts the ability to encode, store, and recall information, as well as the ability to learn new information, take notes, stay on task, and problem solve (Conway & Engle, 1994; Engle, 2002; Rosen & Engle, 1998). Furthermore, working memory capacity is a finite resource that varies in quantity across people, and has been linked to reading comprehension and distractibility (Rosen & Engle, 1998; Robison & Unsworth, 2017). Previous research has indicated that higher working memory capacity is associated with greater ability to allocate attention to specific tasks and avoid distractions (Engle, 2002).

One of the many ways working memory capacity impacts our ability to encode, store, and retrieve information involves its relationship with long-term memory. Individuals with high working memory capacity correctly recall more information from long-term memory than those with low working memory capacity (Unsworth, 2016).

Unsworth (2016) examined the relationship between working memory capacity and recall from long-term memory by measuring the variables that contribute to successful retrieval of information (e.g., encoding strategies, study time allocation, self-monitoring). Working memory capacity was positively related to recall accuracy and the effect was moderate, partial $\eta^2 = .11$. Additionally, individuals with high working memory capacity were less likely to deviate from the task than individuals with low working memory capacity.

Working memory has also been linked to distractibility. Unsworth (2007) highlighted the impact of working memory capacity on suppressing irrelevant information: After completing span tasks designed to measure working memory capacity, participants engaged in delayed and continuous distractor recall tasks. Individuals with higher working memory capacity recalled more items on free-recall tasks at a faster rate than individuals who had lower working memory capacity, and those with high working memory capacity made less intrusions across previous tasks than individuals with low working memory capacity. Unsworth (2007) concluded that the observed effect was likely due to the ability of those with high working memory capacity to suppress irrelevant information from previous exercises during the current task. Unsworth's (2007) findings indicate that those with low working memory capacity are not able to suppress task-irrelevant information as successfully as those with high working memory. This informs the goals of the current study, as it aims to measure students' ability to encode and retrieve information while being introduced to task-irrelevant information (music). In the present study, recall performance was assessed by measuring participants' ability to remember word pairs (akin to the "remember" category of Bloom's (1956) Taxonomy).

Many of the academic tasks students engage in require memorizing semantic information (Mayer, 2002). Although memorizing semantic information is not as complex as activities at higher levels of Bloom's Taxonomy (such as a task that utilizes the "apply" or "analyze" levels), it still requires controlled attention to successfully encode and recall the to-be-learned information (Bloom, 1956; Anderson & Krathwohl, 2001).

Further research by Rosen and Engle (1998) supported the claims of Unsworth (2007). Rosen and Engle investigated the relationship between working memory capacity and individual differences in suppressing intrusive thoughts and/or behaviors. Participants completed complex span tasks in order to measure their working memory capacity, were randomly assigned to an interference or noninterference group, and completed paired-associate learning tasks. Rosen and Engle measured participants' speed and accuracy during the paired-associate learning tasks, as well as their ability to suppress intrusions. Individuals with higher working memory capacity were better able to suppress intrusions and correctly complete the paired-associate learning tasks than individuals with lower working memory capacity, providing further evidence for the relationship between working memory capacity and suppression of task-unrelated thoughts.

Additionally, working memory capacity plays an important role in the recall of information over varying periods of time. Delaney et al. (2017) investigated the relationship between working memory capacity and the spacing effect – or the phenomenon in which greater intervals between study periods leads to an increased chance of remembering the studied information. Individuals with higher working capacity outperformed those with lower working memory capacity on delayed-cued recall tasks. Furthermore, higher working memory capacity was positively correlated with correct answers on delayed-cued recall tasks when items were repeated three or more times. Delaney et al. (2017) indicated that individuals with high working memory capacity tend to outperform individuals with low working memory capacity on tasks of delayed-cued recall tests. Therefore, for the present study, I anticipated that individuals with higher working memory capacity would outperform those with lower working memory capacity.

Working memory is also crucially important in maintaining attention to a specific task, as well as filtering unnecessary information (Robison, Miller, & Unsworth, 2018). Robison et al. examined the relationship between individual differences in working memory and inhibiting unnecessary information. After completing several different span tasks (e.g., reading span, operation span, symmetry span) in order to measure working memory capacity, participants engaged in a filtering task to measure their ability to ignore task-irrelevant information. Individual differences in working memory capacity predicted filtering ability, but the filtering demands changed on a trial-by-trial basis. Robison et al. noted that this criterion must be met in order to observe the effects of individual differences in working memory due to the relationship of the target and distractor being continuously reinforced if the distractor remains the same throughout the remainder of the task. The implications of Robison et al.'s research are numerous for the present study. In addition to the relationship between working memory capacity and remaining on-task, Robinson et al. demonstrated that continuously changing information would require continuous filtering (Robison et al., 2018). Students listening to multiple songs while studying may be continuously having to filter and redirect attention back to the target task after every new song, or, if the song features complex elements (i.e., polyphony), many times during a single song.

Background Music and Attention

Many studies have examined the effects of background music on measures of attention, however, no studies have yet centered on the complexity of music (i.e., its components) and their impact on encoding. Cauchard, Cane, and Weger (2011) examined the effects of background speech and music on interrupted reading. Using eye-tracking, Cauchard et al. measured the time it took for participants to read a passage after being interrupted by a sixty-second audio story. Participants were presented with paragraphs to read while either presented with background speech or instrumental rock music. Reading time increased after the interruption due to participants rereading the passage presented. Neither background speech nor music modified the effects of the interruption; however, reading rates were slower in the background speech condition than in background music or control conditions. This is an important demonstration as it may inform the question of whether speech in music (i.e., lyrics) could impede one’s ability to encode information.

Beanland, Allen, and Pammer (2011) reported that listening to music decreases inattentional blindness. Ashcraft and Radvansky (2010) define inattentional blindness as a phenomenon described by a failure to see an object one is looking at, even directly, due to attention being directed elsewhere. Beanland et al. measured performance on an inattentional blindness task and task-unrelated thoughts while participants listened to music. There were lower amounts of inattentional blindness among those who listened to the music selected by the researchers (Momma Mia! by ABBA), compared to those in the no-music condition. The number of task-unrelated thoughts was lower for those in the high auditory load music condition, but not for those in the low auditory load condition, indicating that music may improve performance on specific tasks, such as an inattentional blindness task, if the music listened to carries specific qualities. This study, as well as research by Jenkins (2001) and Rauscher, Shaw, & Ky (1995) regarding the Mozart Effect, indicate that music may increase performance on some tasks, in contrast to the findings of Cauchard et al. (2011).

There is evidence to support music's effect on a person's ability to encode. El Haj, Omigie, and Clement (2014) tested the effects of music on source memory. Source memory is defined by Ashcraft and Radvansky (2010) as "the exact source of information" (p.36), such as whether someone read information in a book, or was told the information by a teacher. Those who were exposed to background classical music performed significantly worse than those exposed to background noise or silence: exposure to music seemed to impede binding of information in working memory, which disrupted source recall. These results are important, as they suggest that encoding information while listening to music can hinder one's ability to recall the information for later use. However, the musical piece chosen by El Haj et al. (Vivaldi's Four Seasons) introduced potential confounds due to its musical elements varying in complexity, which could have potentially distracted or confused the listener.

Other research has examined the relationship between music preference and attention. Perham and Vizard (2011) examined the influence of music preference on attention and performance tasks by measuring the "irrelevant sound effect." This phenomenon can be described as an impairment of serial recall when unrelated sounds are present. The songs used by Perham and Vizard were chosen based on the researchers' preferences (e.g., the researchers assumed that most people would dislike music from the death metal genre because they did not like death metal). Music preference was measured via a Likert scale presented at the end of the questionnaire. Performance was roughly the same across both liked and disliked music conditions; music preference did not seem to affect attention. However, Perham and Vizard did not control for the various components of each song that could be attributed to a person's preferred music choice (i.e., melody, timbre, tone, etc.), nor did they properly operationally define the music for their liked and disliked conditions (i.e., picking from Billboard Top 100, looking at record sales to determine popular genres and artists, etc.). The results of Perham et al.'s study are important, as they indicate that song choice should not affect the attention of the listener. However, because Perham et al. did not differentiate between different components of music (e.g., genre, tempo, timbre, etc.), it is unknown whether particular components of the songs used may have impacted attention.

Lyrics featured in a song could impact students' ability to encode and recall information while listening to music. Shih, Huang, and Chaing (2012) focused on the effects of lyrical and non-lyrical background music on attention. Those who listened to music with lyrics had lower scores on measures of attention than those who listened to music without lyrics. This demonstrates that it may be counterproductive for students to study to music with lyrics; however, Shih et al. did not elaborate on the other musical components of the pieces used, and used broad definitions of music with and without lyrics. The musical key, rhythm, melody, progression, or complexity could have affected the listener's performance, and were not controlled for by Shih et al. These results contributed to the present study, because music with lyrics was expected to hinder participants' ability to encode, store, and recall information.

Although few studies have examined the frequency of repeated exposure to music and recall ability, Anderson and Fuller (2010) examined the relationship between students' preference to listen to music and their overall performance on reading comprehension tests. Anderson and Fuller (2010) hypothesized that the limited capacity of cognitive resources can influence one's ability to dually process both the lyrical content in songs and the material being read. Participants were asked to listen to background music containing lyrics (which was selected from the Billboard Magazine's Top 100 list) while completing a reading comprehension task; after the task was completed, students were asked to rate their preference for the presence of music played during the allotted study period. The results indicated that those who were in the music condition performed worse on the reading comprehension task than those in the quiet condition, and that the individuals who preferred to listen to music while studying performed worse in both conditions than those that preferred to complete the task in silence. This study demonstrates that music with lyrical content can hinder reading comprehension (Shih et al., 2012). It also shows that individuals who prefer to listen to music during demanding tasks may be compromising their performance on those tasks.

In the present study, I expected participants assigned to simplistic music conditions to perform better than those in the complex conditions because simplistic music may not be as much of a distraction as complex music. Due to the lack of existing evidence on the impacts of complex and simplistic music, as well as the inconsistent results from studies that have studied the effects of background music on attention, the hypotheses focusing on music technicality were largely exploratory. Technicality was expected to have an impact similar to that of lyrics, as technicality represents an additional source of distraction due to the various and sudden tonal changes in the music pieces defined as complex.

Present Study

The goal of the present study was to investigate the roles musical complexity and working memory capacity play in student recall performance. The present study focused on the questions: "Does listening to complex music while studying affect students' ability to accurately recall information, as opposed to listening to simplistic music?" and "Does listening to music with lyrics impair one's ability to recall information previously studied, as opposed to music without lyrics?" The hypotheses of the present study were:

1. Individuals in complex music conditions will recall fewer items on the final recall test than those in simplistic or control conditions.
2. Individuals in music with lyrics conditions will recall fewer items than individuals in non-lyrics conditions, or individuals in the control condition.
3. Lower working memory capacity will be associated with recalling fewer items than higher working memory capacity.

Method

Participants

Approval from the Institutional Review Board at Western Kentucky University was obtained prior to data collection. Participants (*N* = 200) from a large university in the southeastern United States were recruited using Study Board, a research participation system for undergraduate psychology students. Complete data sets were obtained from 191 of the 200 participants. A total of 144 women and 47 men completed the experiment. Participants' ages ranged from 18 to 50 years (*M* = 19.5, *SD* = 3.35). There were 114 (59.7%) college freshman, 45 (23.6%) college sophomores, 21 (11.0%) college juniors, and 11 (5.8%) college seniors. Grade point average ranged from 0.7 to 4.0 (*M* = 3.30, *SD* = .728). All participants were native English speakers.

Materials

The measure used to assess recall performance was a verbatim recall test derived from the Swahili-English word-pair paradigm (Karpicke & Roediger, 2008). This measure has high test-retest reliability (*r*s = .89-94; Bangert & Heydarian, 2016; Nelson & Dunlosky, 1994) and has been frequently used as a measure of recall performance (Karpicke & Roediger, 2008). Paired associate tasks correlate moderately with other measures that assess recall (*r*s = .259-.340; Kyllonen & Tirre 1988). The verbatim recall test consisted of 29 verbatim recall items; participants recalled from memory the complete English translation of the given Swahili word.

The music pieces used were selected and recorded by the researcher and other research assistants. If songs were shorter than the allotted 10-minute study period, the song was set to repeat until the study period was over. In the simple music conditions, homophony was represented by instruments (e.g., drum, bass, multiple guitars, keyboard, synthesizers, etc.) playing melodies, which were always played in unison and never independent of one another, that complemented each other and formed a harmony. In the simple without lyrics condition, the song chosen was 10 minutes and 30 seconds long, had a tempo of 103 beats per minute (bpm) and was in the dark ambient genre. In the simple with lyrics condition, the song was 6 minutes and 29 seconds long, 120 bpm, and was in the alternative acoustic genre. In the complex music conditions, polyphony was represented by instruments playing melodies that were independent from one another, yet harmonized with each other. The song in the complex without lyrics condition was 4 minutes and 17 seconds long, 145 bpm, and in the progressive rock/metal genre. Lastly, the complex with lyrics condition was 5 minutes and 10 seconds long, played at a 150 bpm, and was in the progressive rock/metal genre.

Working memory capacity was measured via two complex span tasks (Operation Span and Symmetry Span tasks) which were administered after the verbatim recall test was completed. Multiple measures of working memory capacity are recommended to ensure reliability of estimates (Foster et al., 2014). Operation Span tasks involve solving a series of simple math problems while attempting to remember a sequence of unrelated consonant letters (Unsworth, Heitz, Schrock, & Engle, 2005). Symmetry Span tasks involve recalling a sequence of red squares in a 4x4 matrix while also engaging in a symmetry-judgment task in which participants are asked to identify whether an image is symmetrical (Foster et al., 2014). For this study, the shortened versions of these tests were used. The shortened version of both the Operation Span and Symmetry Span tasks correlate highly with each other ($r = .53$) and with general measures of fluid intelligence (rs = .52-.67; Foster et al., 2014). Furthermore, the shortened versions of the span tasks used are highly reliable, Cronbach's $\alpha = .83$-.87.

Procedure

After providing informed consent upon arrival, participants were randomly assigned to a music condition: simplistic music with lyrics, simplistic music without lyrics, complex music with lyrics, complex music without lyrics, or control (silence). Participants were given the sheet of 29 Swahili-English word pairs and had 10 minutes to memorize the words and their translations, while being exposed to the song made for the condition they were assigned, for the entirety of their study time. After a five-minute filler task consisting of a number search (i.e., much like a word search, but using numbers instead), participants completed a verbatim recall/matching test over the Swahili-English word pairs. The verbatim recall test took place in silence. After the verbatim recall test, participants completed the Symmetry Span and Operation Span tasks to measure working memory capacity. Next, participants completed a demographic questionnaire. At the end of the study, the researcher indicated the end of the experiment and participants were awarded credit for participating.

Planned Analyses

Descriptive statistics were run in order to report demographic information, the average working memory composite score, as well as the average number of words recalled during the verbatim-recall test as a function of assigned condition and individual difference variables (i.e., working memory). A 3 (complex, simple, control) x 2 (lyrics vs. no lyrics) analysis of covariance (ANCOVA) was run in order to determine the effects of music condition and working memory on retrieval performance.

Results

The overall verbatim recall score ranged from 0 to 29 (M = 10.69, SD = 7.02). A composite working memory score was calculated by standardizing the Symmetry Span and Operation Span working memory scores and averaging them together (Unsworth, 2007). The working memory composite score ranged from -6.09 to 2.91 (M = .0045, SD = 1.67).

Table 1

Mean Recall Performance by Condition

Condition	Lyrics		No Lyrics		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Complex	9.85	6.99	11.05	6.07	10.45	6.53
Simple	10.12	7.72	12.49	7.36	11.30	7.58
Total	11.75	6.72	10.00	7.31		
Control	10.31	6.93				

Table 1 contains the mean scores for each music condition, as well as means across lyric conditions and across music simplicity and complexity conditions. As can be seen in Table 2, there were no significant differences in recall performance due to music simplicity or complexity. Those in complex conditions did not perform significantly differently than those in simplistic or control conditions, failing to support the hypothesis that the musical components of polyphony or homophony impact recall performance. Lyrics did not have a significant impact on recall performance (see Table 2). Therefore, individuals who were in lyric conditions did not perform significantly differently than those in non-lyric conditions, failing to support the hypotheses that lyrics, or songs featuring complex musical components (i.e. polyphony) with lyrics, would impede recall performance. As expected, working memory capacity had a significant impact on recall performance: Higher working memory capacity was associated with recalling more Swahili-English word pairs, $r = .21$, $p = .003$.

Table 2

The Impact of Working Memory, Lyrics, and Musical Components on Recall Performance

Source	*df*	*Mean Square*	*F*	η_p^2	*p-value*
Working Memory Composite	1	356.47	7.53	.039	.007
Simple vs Complex	1	32.76	.69	.004	.407
Lyrics vs no Lyrics	1	110.79	2.34	.012	.128
Simple/complex x lyrics/no lyrics	1	35.74	.76	.004	.386
Error	185	47.36			

Discussion

Music components did not have a significant effect on recall performance. Individuals who studied while listening to music containing polyphony, homophony, lyrics, or no lyrics did not perform significantly differently from those who studied in silence. Furthermore, performance in each condition did not differ significantly from other conditions (e.g., simple versus complex, lyrics versus no lyrics). These findings conflict with previous research indicating that music may impact performance on tests of attention or encoding (El Haj et al., 2010; Shih et al., 2012). There are a few possible explanations as to why music did not have a significant effect on recall in the present study. Firstly, although the music used in the present study was designed to meet the operational definitions of simplicity and complexity, it featured musical elements that most people were likely unaccustomed to. The music was chosen in order to create a novel experience for the listener, as well as to eliminate the chances that the song had been heard before, as this would produce additional confounds. However, efforts to ensure novelty and distinctiveness of the music for each condition resulted in each condition having different music genres and time signatures.

Additionally, the songs used in each condition were of different lengths. Each participant listened to the music associated with their assigned condition for the entire duration of the study period (10 minutes); however, some of the songs used were 10 minutes long, while other songs repeated two or more times. There is a chance that this repetition allowed listeners to acclimate to the songs that featured a repetition over the course of the study period.

Although the impact of music condition on recall performance was not significant, working memory capacity had a significant effect on performance. As expected, individuals with higher working memory capacity outperformed those with lower working memory capacity. Those with higher working memory capacity have more mental resources to help them retain and recall information after encoding (Unsworth, 2016), and are better at filtering out distractions (Robison et al., 2018). Therefore, those with higher working memory capacity may have been better able to filter out distracting musical components, melodies, or general features (e.g., lyrics, time signatures, chord progressions, etc.) of the songs used than individuals with lower working memory capacity, and thus perform better on the verbatim recall task.

Limitations and Directions for Future Research

As previously discussed, the songs used in the present study were of different lengths. Due to the possibility that some conditions' songs repeated and potentially allowed for listeners to acclimate to the music, future research should use songs of similar length or songs that last the entirety of the study period. Not only were the songs different lengths, but they did not all share the same genre: The songs in the complex music conditions were progressive rock/metal, while those in the simplistic conditions were black ambient and alternative acoustic songs. Therefore, it would be beneficial for future research to utilize songs that are more consistent or share the same genre. Additionally, in order to improve ecological validity, future researchers may wish to use music containing elements similar to what students typically listen to (e.g., music from the Billboard Top 100 charts). As previously stated, the songs used in the present study also had differences in key, tone, effects, and time signature. It is difficult to remove all confounds from music. However, for the sake of research on the impact of particular musical elements, it would be best if the songs used in future studies were as close in key, melody, and time signature as possible.

Although previous research has indicated that song preference does not impact recall performance (Perham & Vizard, 2011), it would be interesting to record preference for the songs played during an encoding task. Doing so could provide more insight into the impact of music preference on performance during cognitively demanding activities. Future researchers may also wish to investigate the impact of listening to one's own preferred music while studying, as opposed to music assigned by researchers. Furthermore, although the present study measured working memory capacity via complex span tasks, it would be beneficial for future research to vary the cognitive demand of the dependent variable in order to further investigate the relationship between working memory, music, and recall performance.

It would be also advantageous for future research to focus on the novelty of the music pieces used, to determine whether novelty/familiarity of songs or musical components impact encoding and recall performance. Now more than ever, songs in foreign languages are gaining massive popularity in the United States, Mexico and the United Kingdom (Todd, 2018). Future researchers may wish to investigate students' ability to encode and recall information while studying to music containing lyrics in a language foreign to the listener. Furthermore, it would be interesting to see how well students encode and recall information while listening to music with lyrics in a foreign language that contains or lacks cognates of the listener's native language.

The impact of how often individuals listen to music while studying semantic information is largely unknown. Therefore, it would be beneficial for future research to focus on how well students who normally listen to music while studying can engage in encoding and retrieving semantic information while listening to music. Although previous research has studied the role of specific personality traits (e.g., extraversion) and distractibility due to music (Mistry, 2015; Standing, Lynn, & Moxness, 1990), it would be interesting to investigate the impact of specific musical components on this relationship.

It is also possible that the impact of music during studying may differ as a function of the task at hand (e.g., mathematical problem-solving vs. reading comprehension), particularly if those tasks are more similar to the types of task students typically do while listening to music. Therefore, future researchers may wish to use more than one type of dependent measure. Lastly, future research should focus on investigating the purpose of the music while studying (e.g., is it meant for the enjoyment of the listener, or is it meant to drown out environmental noise?). This may impact how much the student is paying attention to the music while studying, potentially impacting how well they encode and recall information.

Conclusion

The present study indicated that recall performance does not vary as a function of whether music contains polyphony, homophony, or lyrics. Whether studying paired associates in silence or in the presence of music, individuals with higher working memory capacity were better able to study (encode and recall) information than individuals with lower working memory capacity. The results of the present study have implications for future researchers who wish to investigate the role of musical components on recall performance, as well for those who aim to further explore the relationship between working memory and recall.

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APPENDIX A

English Swahili Word Pairs

Study the word pairs below. On the test, you will see the Swahili word and be asked to write the corresponding English word.

Swahili	English
Ankra	Invoice
Chimbo	Quarry
Fahali	Bull
Fununu	Rumor
Gharika	Flood
Gutu	Stump
Hadithi	Story
Kaburi	Grave
Kaputula	Shorts
Kamba	Rope
Ladha	Flavor
Lawama	Blame
Malkia	Queen
Mshoni	Tailor
Nabii	Prophet
Nafaka	Corn
Pazia	Curtain
Pipa	Barrel
Rembo	Ornament
Ruba	Leech
Sala	Prayer
Tajiri	Merchant
Talaka	Divorce
Theluji	Snow
Tumbili	Monkey
Ubini	Forgery
Vuke	Steam
Wasaa	Leisure
Yamini	Oath
Zulia	Carpet

APPENDIX B

Filler Task

Number Search

0	8	9	1	1	6	4	7	3	5	1	5	1	8	2	4	7	4	8
6	3	9	1	9	7	9	6	1	1	8	1	8	3	4	4	7	6	0
0	1	0	1	3	4	3	1	0	4	5	9	1	5	2	8	0	4	7
9	2	7	2	0	4	1	9	5	0	0	0	3	9	3	6	8	1	0
0	6	8	4	8	3	4	2	1	2	7	4	4	1	3	7	7	0	0
4	3	4	3	8	9	3	0	3	0	5	7	0	2	9	9	3	7	2
6	6	7	1	6	5	9	2	1	9	6	8	8	9	1	4	5	3	4
0	6	3	8	8	5	0	9	2	8	4	2	9	3	3	3	9	1	0
8	5	7	4	1	2	3	0	8	9	7	2	1	3	6	9	7	8	6
7	5	8	1	9	5	6	2	2	8	8	5	6	6	6	3	3	1	3
0	1	5	7	0	8	2	6	9	3	5	0	7	4	9	5	6	3	9
9	2	5	3	1	2	9	3	8	1	5	8	0	0	6	7	1	1	6
7	9	7	2	3	2	8	5	7	3	3	1	9	1	9	4	6	5	0
1	8	7	3	8	3	3	2	8	4	2	4	7	8	4	5	5	3	6
2	4	3	1	3	5	1	9	4	4	7	5	2	9	3	0	5	5	6
8	2	9	6	8	8	6	3	7	7	2	8	8	2	9	1	3	5	9
4	4	2	3	8	1	9	4	3	7	2	0	4	2	7	5	6	5	5
9	4	0	9	4	3	7	5	0	8	1	5	9	5	4	7	5	4	1
3	9	5	7	5	8	3	5	9	4	5	0	7	8	3	2	6	0	1

4372	9103	5078
7531	8070	1647
5973	6969	1528
7029	6401	9796
8976	1089	3960
1284	9202	7508
5647	2508	1829
3254	3430	6029
6949	3934	0578
1971	3957	9167
1028	1850	8312
4275	8269	3935
8013	4094	2474
4310	1590	1326
1274	3581	1298
2356	1458	6382
9134	4035	

APPENDIX C

INFORMED CONSENT DOCUMENT

Project Title: Language Recall Study
Investigator: Dane Adkins, Department of Psychology, (423) 240-6580

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your agreement to participate in this project.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have. You should keep a copy of this form for your records.

If you then decide to participate in the project, please click the "agree" button below.

1. **Nature and Purpose of the Project:** The purpose of this project is to examine student language recall under different environmental conditions.

2. **Explanation of Procedures:** You will study a list of words and be tested over them.

3. **Discomfort and Risks:** There are no anticipated risks.

4. **Benefits:** Participants will learn about psychology research, and earn Study Board credit.

5. **Confidentiality:** Participants' names will not be associated with their data except during initial data collection. All materials will be locked in the Attention and Memory Lab in Gary Ransdell Hall and/or stored on password-protected computers.

6. **Refusal/Withdrawal:** Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

By clicking "agree" you agree to provide informed consent for this study.

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-2129

WKU IRB# 16-233
Approval - 2/05/2018
End Date - 12/10/2018
Expedited
Original - 12/10/2015

APPENDIX D

Verbatim-Recall Test

For each Swahili word, type the English word that means the same thing. You will have ten minutes to answer as many as you can. When you have answered as many you are you able, click the arrow at the bottom of the screen.

Lawama

Mshoni

Wasaa

Nabii

Gharika

Ubini

Sala

Sala

Nafaka

Vuke

Kamba

Pipa

Zulia

Fahali

Tumbili

Chimbo

Malkia

Hadithi

Kaputula

Talaka

Gutu

Tajiri

Theluji

Rembo

Ankra

Fununu

Ladha

Ruba

Kaburi

Pazia

APPENDIX E

Demographics Questionnaire

Year in school:

- Freshman
- Sophomore
- Junior
- Senior

Sex:

- Male
- Female
- Other
- Prefer not to answer

Age:

What is your major?

Have you taken at least one previous semester of classes at WKU?

- Yes
- No

What was your ACT composite score? Write N/A if you did not take the ACT.

Score:	
Year taken:	

What was your SAT composite score? Write "N/A" if you did not take the SAT.

Score:	
Year Taken:	

Do we have permission to access your ACT/SAT scores on TopNet?

- Yes
- No

Is English your first language?

- Yes
- No

Do you speak any languages other than English?

- Yes
- No

If yes, please list all other languages you speak and your proficiency level below:

How often do you listen to music while studying?

- Never
- Less than half the time
- About half the time
- Almost Always
- Always

What kind(s) of music do you listen to while studying?

Do you play an instrument?

- Yes
- No