NO SIGNIFICANT DIFFERENCE IN MEMORY PERFORMANCE BETWEEN MUSIC WITH LYRICS AND MUSIC WITHOUT LYRICS

by

Adam C. Runyan

An Abstract
of a thesis submitted in partial fulfillment
of the requirements for the degree of
Masters of Science
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ABSTRACT

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Many people listen to music while completing important tasks. In the present research we investigated the effects that lyrics in music have on memory performance. A working memory model was the basis for the formation of the hypothesis that lyrics in music would interfere with the storing of information into long-term memory. Participants were randomly divided into one of three groups corresponding to which of three audio clips they listened to while reading and attempting to remember a list of words. The conditions participants were placed into were the control condition (sound of running water), instrumental music, and music with lyrics. Each participant read a list of words, completed two forgetting tasks, later attempted to recall words from the original list, and gave each recalled word a confidence rating. Results revealed no significant differences among the groups in the mean number of words correctly recalled or in the confidence ratings of those correctly recalled words. We conclude with a discussion of nonsignificant findings and proposed directions of future research.

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CHAPTER 1

OVERVIEW

The purpose of this study is to determine if introducing music while participants encode a word list affects participants' word-recall ability. The present study was designed to explore music's role in interference of the semantic aspect of working memory. Planned contrasts were used to determine if participants that listen to music with lyrics during the encoding task perform significantly worse on the dependent variable of memory recall compared to those who listen to music without lyrics or to a control condition with no music. This research is important because it will help determine if people are unknowingly causing their memory to suffer during important tasks. For example, listening to music while studying for an exam may result in poorer exam results compared to not listening to music; further, someone listening to music with lyrics will likely have a poorer performance when compared to someone listening to music without lyrics. The working memory model that is described and analyzed in subsequent chapters is used as the theoretical framework for the hypothesized differences in the semantic aspect of working memory. If the differences between the three groups are significant, there are large implications that should be addressed.

Rationale

People often listen to music while doing important tasks such as studying, reading, writing, and doing research (Goldstein, 2013). It is useful to know whether listening to music while doing such important tasks interferes with the encoding and retrieval process of important information. If results reveal that people who listen to music with lyrics during encoding perform significantly worse than people listening to no music or music without lyrics, this issue

needs to be addressed. Finally, this research will focus on the role of the semantic memory aspect of working memory.

Baddeley (2012) has been investigating working memory (WM) for over 50 years and has written many works explaining his proposed working memory model. The present research is based on his most recent WM model. Baddeley (2012) explained that research needs to be done in order to develop the model; "as we begin to fill in the empty spaces on the theoretical map, it hopefully will be increasingly possible to develop interlinked and more detailed models of the components of WM and their mode of interaction" (p. 25). Developing this WM model will allow for more exploration of the topic of semantic memory and may lead to further memory questions being answered. More research on semantic memory has many implications including the one addressed in this study, as well as, "human factors to psychiatry, neuropharmacology to language therapy, and even to paleoanthropology" (Baddeley, 2012, p. 24).

Many research studies have investigated working memory and memory performance (Anderson, Reder & Lebiere, 1996; Baddeley, 2012; Baddeley, 2007; Platel et al., 1996; Christopher & Shelton, 2017). The present study specifically investigates the role semantic memory plays in memory recall. The purpose is to investigate whether semantic memory is impaired by listening to music with lyrics during a simple encoding task. Researchers measured the mean number of words correctly recalled and the mean recall confidence ratings of correctly recalled words in three experimental conditions. Recall confidence is a dependent variable in this study because it is important to understand whether or not people think they remember better if they listen to music during encoding in addition to measuring their actual memory performance. Researchers have found inconsistent evidence correlating confidence ratings with

actual memory performance (Maki, Shields, Wheeler, & Zacchilli, 2005; Solso & McCarthy, 1981).

Baddeley and Hitch (1974) first proposed a working memory model that was distinctive from all other models because their model accounted for the idea that "mental operations performed on information in conscious awareness can be carried out independently of interactions with, or influence on, LTM" (Postle, 2015, p. 368). The model has evolved over the decades to include several components, those being the visuospatial sketchpad (VSSP), the phonological loop (PL), and the central executive (CE). The VSSP accounts for visuospatial memory input, the PL accounts for verbal input, and the CE controls which component, the VSSP or PL, is allowed more resources or attention.

Baddeley (2012) revised his previous working memory model to include an episodic buffer, which can be considered the "working link" between working memory, perception, and long-term memory. The episodic buffer "can hold multidimensional representations, but like most buffer stores it has limited capacity" (Baddeley, 2012, p. 15). The limited capacity of the episodic buffer explains why there is a gap in recall abilities seen in memory research; therefore, the limited capacity of the episodic buffer can explain the phenomenon of the primacy and recency effects which will be described later in the literature review. The goal of the proposed research is to test the following hypotheses about the role of the semantic component of Baddeley's working memory model. Testing the hypotheses of the present study will help to further evaluate Baddeley's working memory model.

Hypothesis 1a

Participants in the control condition, who listen to natural sounds (i.e., running water) while studying a list of words, will recall significantly more words compared to participants in

the experimental groups (conditions that involve participants listening to music during encoding). A higher number of words will be recalled in the control condition because both experimental conditions involve participants listening to music during encoding. During encoding, the instrumental music condition will result in some interference in the PL, while the music with lyrics condition will have increased interference in the PL. The literature review chapter will cover details as to why participants in the lyrics with music condition will have more interference in the PL than participants in the other two conditions. Having one of the three main components on Baddeley's working memory model occupied during an encoding task should result in poorer memory performance when compared to the control condition.

Hypothesis 1b

Participants in the control condition will report significantly higher confidence ratings than participants in the experimental conditions. Participants who do not listen to any music during the encoding task are allowed to rehearse the words in their heads. Rehearsal is considered one of the most widely used "memory tricks" that people use in order to remember lists of things (Goldstein, 2013). People in the experimental groups should have a harder time rehearsing the list of words, due to the task of listening to music, which should result in poorer memory performance compared to the control condition.

Hypothesis 2a

Participants in the instrumental music condition, who listen to music without lyrics while studying a list of words, will recall significantly more words than the participants in the music with lyrics condition. Participants in the instrumental music condition will have an occupied PL because of the acoustic music playing during the encoding task. However, the participants in the music with lyrics condition will have a task that involves much more interference in the PL due

to the encoding of the music, the lyrics, and the list of words. The participants in the music with lyrics condition will listen to music with lyrics, which involves possibly visualizing the lyrics and thinking about the lyrics all while trying to encode the words on the original list. Participants in the music with lyrics condition should recall a significantly lower number of words than participants in the instrumental music condition. Finally, participants in the instrumental music condition should recall a significantly lower number of words compared to the participants in the control condition.

Hypothesis 2b

Participants in the instrumental music condition will report a significantly higher confidence rating than the participants in the music with lyrics condition. The task of remembering a list of words while listening to music with lyrics heavily taxes the PL. Due to the overloaded PL, participants in the music with lyrics condition should not be as confident in rating whether or not the word recalled was on the original list. In other words, the lyrics in music should interfere with participants' PL's ability to encode and/or retrieve information.

CHAPTER 2

LITERATURE REVIEW

There are many different memory theories that explain things such as why people forget certain things but remember others (Baddeley, 2012; Ranganath & Blumenfeld, 2005). Factors such as how often a memory is recalled and other environmental stimulation affect one's ability to recall memories (Goldstein, 2013). Some memory models are complex but do not account for certain aspects of short-term or long-term memory (Ranganath & Blumenfeld, 2005). Other theoretical models appear to be inclusive of different kinds of memory, are productive in research, and increase knowledge of memory (Baddeley, 2012). Different models account for specific memory effects such as the Primacy and Recency effects, the word-length effect, and the phonological similarity effect (Goldstein, 2013). This chapter will highlight and explain different aspects and components of a specific memory model. Additionally, this chapter will investigate different effects of music on memory tasks, review other working memory literature, and focus on one component of WM that seems to be the key to understanding how music affects memory. This review will conclude with the suggestion that Baddeley's WM model is the best framework for understanding music's effect on memory, and specifically, how and why the model predicts an effect of musical lyrics on WM.

Many researchers have concluded that there are two different memory stores: short-term memory (STM) and long-term memory (LTM) (Alley & Greene, 2008; Baddeley, 2012; Cocchini, Logie, Della Sala & MacPherson, 2002; de Groot & Smedinga, 2014; Ranganath & Blumenfeld, 2005). STM is described as a memory store for small amounts of information for very brief periods of time (Baddeley, 2012). A STM example would be writing down a phone number that one just heard on a voicemail immediately after hanging up the phone. There is a

common misconception outside of memory literature that long-term memories are memories that happened several days, weeks, months, or years in the past; within the memory literature, researchers agree that LTM includes any memory that has happened 30 seconds in the past and beyond (Baddeley, 2012; Gazzaniga, Ivry, & Mangun, 2014). There are other memory models that may help explain LTM (Chase & Ericsson, 1982; Ericsson & Kintsch, 1995) but the present research is based on Baddeley's (2012) most recent multi-component WM model.

Baddeley's Working Memory Model and the Central Executive Component

WM has been defined in terms of how information is stored temporarily and used to accomplish a task (Ricker, AuBuchon, & Cowan, 2010; Miller, Galanter, & Pribram, 1960); for the purposes of the present research WM is defined by Baddeley as the temporary store of information, through the use of a multi-component system, which is used to complete cognitive tasks (Baddeley, 1992; Baddeley, 2012). Baddeley's multi-component WM model consists of four main components, all of which will be described in this chapter. The first component of Baddeley's WM model is the CE component. The CE is characterized by Baddeley (2012) as the homunculus of working memory. The main functions of the CE are to focus attention, divide attention between different stimuli, divide attention between different tasks, and interact and feed information from WM to LTM. The last function of the CE, the ability to interface with LTM, is of particular interest in the present research because the CE has to function with other components in order to move information from WM to LTM. Baddeley claims that the CE allows other components, such as the VSSP and the PL, to work together in a specific task in order to achieve the highest performance possible (Logie, Del Sala, Wynn & Baddeley, 2000). There have been numerous studies confirming that the CE allows, or controls, the switch of informational coding from one component to another (i.e., from information being coded into the

VSSP and switching to being coded into the PL) (Posner & Keele, 1967; Kroll, Parks, Parkinson, Bieber & Johnson, 1970). The relationship between the CE and the PL is of primary concern regarding the present research and will be highlighted in a later section.

Visuo-spatial Sketchpad Component

The VSSP is the component of WM that controls the types of WM information regarded as visual and spatial. The VSSP can code information gathered from the environment in one of two ways. Information coded as visual is important for skills such as object recognition and the ability to see details of something after it has left the field of view (Baddeley, 2012; Goldstein, 2013). An example of a visual memory task would be a task that involves observing someone tap a sequence of blocks and duplicating the sequence; this block-tapping task is known as the Corsi block-tapping test (Milner, 1971). Further, spatial memory involves knowing where one is in space, or for example, remembering where a friend parked a car, e.g. down the street and a couple of blocks over from a favorite park. Another example of utilizing the VSSP would be trying to remember the layout of a house after the blueprint has disappeared from the computer screen; one would be using one's visual memory to see the actual blueprint and one's spatial memory to work one's way around the blueprint.

Episodic Buffer Component

The Episodic Buffer (EB) component of Baddeley's WM model is the newest addition to the model itself. The EB is considered episodic in nature because it holds episodes of time in a multidimensional code (Baddeley, 2012); moreover, the EB allows one to remember a high amount of detail from different senses (E.G., smell, vision, sound, etc.) during a single episode in time. For example, the EB allows for people to remember where they were, what they were doing, and what they were wearing during the terrorist attack on September 11th. The EB also

links perception to WM, and WM to LTM. In other words, the EB is more than just a buffer store; the EB also accounts for attention and conscious awareness. The EB is the most novel component, yet is considered the missing link for the WM model. The EB is still very new but has been gradually accounted for via researchers implementing the EB into their theories and research (Baddeley, Eysenck, & Anderson, 2009). The EB allows for increased storage capacity between WM and LTM, a feature that was not previously accounted for in earlier models of WM (Goldstein, 2013).

Phonological Loop Component

The final component of Baddeley's WM model is the Phonological Loop (PL). (Baddeley, 2012). The PL is the component involved in working memory that is of particular importance in regard to the present research because it interacts with LTM and allows people to remember phonologically coded information such as number or word sequences. Baddeley, Gathercole, and Papagno (1998) summarize the purpose of the PL in their own words:

> The loop is specialized for the retention of verbal information over short periods of time; it comprises both a phonological store, which holds information in phonological form, and a rehearsal process, which serves to maintain decaying representations in the phonological store. This relatively simple model has proved capable of accommodating a great deal of experimental evidence from normal adult participants, children, and neuropsychological patients (p. 158).

The PL's interaction with LTM is the specific relationship that is the basis of the hypotheses for the present study. Specifically, the hypothesis that participants who listen to music with lyrics while encoding a list of words will perform poorly at a memory task is based on the concept of interference in the PL from the lyrics in the music. In other words, the lyrics in the music should

deplete PL storage capacity due to the holding of the lyrics in phonological form. Moreover, in addition to interfering with the encoding of information in the PL, the presence of lyrics in music may interfere with the ability to rehearse a list of words. The following sections in this literature review describe specific effects that have been shown in the past to affect certain types of WM.

Phonological Similarity Effect

Salame and Baddeley (1982) first identified the problem that this study aims to further investigate, that being, does listening to music with lyrics significantly affect people's ability to recall information? Salame and Baddeley (1982) found that unattended speech causes memory impairments for visually presented digits. However, the researchers reported further evidence that listening to nonsense words impaired the recall of a list of learned words more so than nonsense syllables did. The five studies done by Salame and Baddeley (1982) give apparent evidence for the phonological similarity effect, that being, recall of a certain stimuli will be more impaired when similar stimuli are presented before recalling the target stimuli. For example, participants presented with a list of letters to remember will have a harder time recalling a list of the letters that are similar in sound (i.e. D,G,B,E,P) versus a list that is dissimilar in sound (i.e. A,Z,D,M,L). Another example more relevant to the present study is a task that requires participants to speak aloud a list of words while listening to music; the task of remembering the word list would be very difficult if the music had lyrics similar in sound to the words the participants are attempting to remember.

The Word-length Effect

The word-length effect essentially implies that longer words (e.g., *metacognition*) are more difficult to remember than short words (e.g., *car*) when presented in a list of words. The PL is where this effect takes place; words that take longer to pronounce use more capacity in the

PL because the information is represented in a sound-based form. For example, someone would have a less difficult time remembering this list of words: car, tan, gym, bank, sky, and drop; versus this list of words: metacognition, implications, acknowledges, maximization, observations, and unforgettable. The word-length effect is important in memory research in regard to the selection of stimuli used in a list of words. Further, this effect was considered when selecting the stimuli to be used in the word list for the present study. A few of the words used in this study were: *Controlled, Fitted, Celebration, Doorway*, and *Drastic*; all of the 16 words used in this study were between six and eleven letters long in order to create a mild to high level of interference in the PL of participants.

The Primacy and Recency Effects

Free recall is a commonly used methodology in memory research (Miller, Galanter, & Pribram, 1960); therefore, one should be aware of these effects when interpreting the results of any free recall study. A list of items (e.g., words) is presented to a participant who attempts to memorize the items for later recall. Participants are asked to remember and report the list of words in any order. Free recall is used in many memory studies (Goldstein, 2013) but the process of free recall presents a problem in regard to the proportion of words recalled. For example, participants will almost always remember the first few words more so than the words in the middle of the list; this is called the Primacy Effect. Similarly, the Recency Effect occurs when participants recall a higher proportion of words that appear toward the end of the list (Miller, Galanter, & Pribram, 1960). Miller and colleagues (1960) describe the Primacy and Recency Effects together as a serial-position curve because the percentages of words recalled toward the beginning and end of a list tend to be much higher than the percentage of stimuli recalled in the middle of a list.

Familiar Music Affects Memory

Pring and Walker (1994) tested working memory in the presence of unvocalized nursery rhymes and traditional instrumental music. Pring and Walker hypothesized that the memories their participants had of the (unvocalized) nursery rhymes would interfere with the PL and cause poorer memory performance. Their rationale was that participants would remember the lyrics in the nursery rhymes, which should result in a smaller PL capacity, which then should prevent participants from storing other sound-based information in the PL. Pring and Walker (1994) found such an effect, where a suspected 'familiar' tune caused impairment in participants' WM when compared to other instrumental music. However, Pring and Walker (1994) did not have a condition that included lyrics or vocal music.

Pring and Walker (1994) revealed an effect that music had on memory very similar to the Mozart effect, which essentially states that Mozart music (e.g., a piano concerto) and other classical music increase memory retention. Steele (2003) reviewed the work done by Rauscher, Robinson, and Jens (1998) in which they exposed rats in utero to Mozart music then later had the rats perform a T maze. Rauscher and colleagues (1998) concluded that rats exposed to the Mozart music before birth completed the T maze significantly faster than the rats that were not exposed to Mozart music. However, Steele (2003) noted that rats are born deaf; therefore, the effect reported in their research had to come from incomplete use of random assignment. Moreover, Steele (2003) wrote about the comparison between human and rat audiograms and concluded that adult rats cannot hear most of the notes in the sonata used in the research by Rauscher et al. (1998). The evidence for the Mozart effect is questionable due to issues such as these as well as a lack of replicability (Steele, 2003).

The study by Pring and Walker (1994) and some evidence from research regarding the Mozart effect (Wilding, Mohindra & Breen-Lewis, 1982) gives a rationale as to why participants in the current study were asked what their preferred music genre is. Additionally, participants were asked whether or not they recognized the song they heard in the study because participants that know and like a song may have intensify affect while listening. Intensified affect has been shown to increase memory performance in certain tasks such as spatial memory (Rauscher, Shaw, & Ky, 1995).

Music with Lyrics in Memory Research

Iwanga and Ito (2002) had participants complete a spatial memory task, a verbal memory task, and a mental arithmetic task while listening to music with lyrics, listening to music without lyrics, listening to the sounds of moving water, and listening to no music. These researchers were trying to determine which condition resulted in the most interference and disruption of participant performance for each task. The verbal memory task required participants in each of the sound conditions (i.e. instrumental music) to memorize a list of five combinations of four words, which were presented for four seconds with two seconds between each combination of stimuli. The recognition phase involved participants making old ("I saw these words in this order before") or new ("this order of words is new to me") judgments on the stimuli presented.

The spatial memory task consisted of presenting ten asymmetric patterns of lines that had 7 to 12 lines in each drawing. Each pattern was shown for three seconds with two seconds in-between each pattern; participants were instructed to memorize each pattern. The recognition phase of the spatial memory task involved presenting five old and five new patterns to participants, who were instructed to make old/new judgments for each design. The mental arithmetic task was not described by Iwanga and Ito (2002).

Iwanga and Ito (2002) measured the perceived disturbance for each task in the three noise conditions on a Likert scale (1-not at all disturbing; 7-very disturbing) as well as recorded correct responses and participant reaction time for each participant; the correct response percentage was calculated for each participant task and each sound condition. The researchers used the median reaction time for correct responses for the analysis procedure. A two-way mixed-design ANOVA (sound conditions x tasks) was used to analyze the data. Results revealed that the perceived disturbance of this sample was highest in the vocal music condition for both the verbal and spatial memory tasks. Further, Iwanga and Ito (2002) reported that their sample showed a disturbance in actual memory performance in only the verbal WM task under the music with lyrics condition as well as the music without lyrics condition. However, it is important to note that the disturbance in memory performance in the music with lyrics condition may have resulted from fatigue due to the nature of the within-subjects design. For example, it is possible that this performance difference may not have been significant if a between-subjects design was used.

The findings from Iwanga and Ito (2002) revealed that participants perceived and experienced a more difficult time completing the verbal (i.e., the PL was being occupied/taxed by the lyrics) and spatial memory (i.e., the VSSP was being occupied/taxed by the lyrics) tasks when they were listening to music with lyrics. Furthermore, actual memory performance revealed that those participants who listened to music with and without lyrics performed significantly worse on only the verbal WM task. One possible explanation for these results was that participants' PL was being depleted due to the lyrics in the music with lyrics condition. In regard to the participants in the music without lyrics condition, perhaps their poorer performance on the verbal WM task was due to the familiarity of the song, which was not measured by Iwanga and Ito (2002). These findings are noteworthy in that they provide evidence for and

against two different hypotheses in the present research. It is hypothesized in the current research that participants who listen to music with lyrics will perform significantly worse than those participants who listened to music without lyrics during the encoding task. Iwanga and Ito's results reveal that there was no significant difference in memory performance between the group of participants that listened to music with and without lyrics. However, in the current research, a song will be used that most, if not all, of the participants will not be familiar with (e.g. a song from another country converted into English), something Iwanga and Ito (2002) failed to implement in their research.

Familiar Music with Lyrics and Metacognitive Judgments

Alley and Green (2008) had all their participants listen to vocal music, instrumental music, irrelevant speech, and sit in silence in order to determine what aspect of music was causing memory impairment, and to what extent. The dependent variable that Alley and Green (2008) used was a measure of WM, specifically a digit span task consisting of "seven random sequences of ten digits each" (p. 282) presented on a screen for .8 seconds each. The participants were instructed to write down the digits in the order they were presented, immediately after viewing the last string of digits; participants were given up to 20 seconds to do so. The researchers then gave headphones to the participants and instructed them to adjust the volume to a comfortable level before going through all of the conditions. Each participant completed the digit span task in a silent condition, while listening to one of two extremely popular pop songs with lyrics, while listening to the other pop song without lyrics, and while listening to irrelevant speech (from an audio book reading). All four conditions were presented to participants in quasi-random fashion ensuring conditions one, two, three, and four were presented the same number of times across all participants, using a within-subjects design.

Results from Alley and Green (2008) revealed that all groups of participants ranked that they felt they performed best in the silent condition, then the instrumental music condition, the irrelevant speech condition, and finally the lyrical music condition. Participants' rankings of how they performed is an example of a metacognitive judgment; metacognition is defined as "the role of executive processes in the overseeing and regulation of cognitive processes" (Livingston, 2003, p. 2). Further, metacognitive judgments in memory research typically involve participants rating how well they performed a memory task, or participants' prediction about their future performance (Tulving, 1985). Alley and Green (2008) used a one-way within-subjects ANOVA to compare the overall means of each background condition (i.e. vocal/instrumental music, irrelevant speech, and silence), finding a significant difference between the groups. The poorest digit-span performance came under the vocal music condition (about 4.8 numbers recalled) and the best participant performance for the digit-span task came under the silence condition (about 5.4 numbers recalled). Finally, it is important to note that the silent condition did not differ significantly from the instrumental condition, which is congruent with one of the current study's hypotheses.

Alley and Green (2008) wrote about the importance of the PL and how it allows "subvocal articulation of verbal material" (p. 278), e.g., the ability to rehearse and remember a grocery list. Furthermore, Alley and Green (2008) described the importance of irrelevant speech in research regarding WM tasks during any kind of speech-present condition. Alley and Green (2008) stated that if irrelevant speech can interrupt WM and PL performance, then other relevant speech may cause further detriments to PL performance.

In the present study, following methodological suggestions by Alley and Green (2008), participants were asked which condition they perceived to be more disruptive, and their familiarity with the song (both on a Likert scale). Participants were asked about their perceived performance, which is a metacognitive judgment, because it is important to know whether or not a perception of disturbance leads to actual memory disturbance (Maki, Shields, Wheeler, & Zacchilli, 2005). Metacognitive judgments are often used in memory research in addition to measures of actual memory performance (Maki et al., 2005). Moreover, researchers are learning about the importance of individuals' ability to monitor their own cognitive processes. Finally, metacognition is related to but distinct from actual memory performance (Maki et al., 2005; Weil et al., 2013).

Summarizing the Basic Effects

The Primacy and Recency effects, along with the word-length effect, are important to remember and consider when developing a methodology that will be used to evaluate WM and LTM performance. The Primacy and Recency effects (Glanzer, 1972; Baddeley, 2012; Craik & Lockhart, 1972) reveal that stimuli at the beginning and end of lists are remembered better than stimuli towards the middle of the list. These two effects are not specifically attributed to the PL, but should be considered for the present study as a free recall task will be employed. The word-length effect must also be considered when considering WM tasks; longer words are more difficult to remember when recalling a list of words.

Summarizing Effects at the Phonological Level

There are numerous effects that are attributed to disturbance or interference in the PL. An effect that can be explained by exploring interference at the phonological level is the phonological similarity effect (Conrad, Baddeley, & Hull, 1966; Salame & Baddeley, 1982).

The phonological similarity effect implies that similar sounding stimuli are more difficult to remember than dissimilar stimuli. The explanation is that the PL will be taxed with the difficult task of trying to remember and keep separate several words that sound similar. Moreover, Pring and Walker (1994) give evidence that a familiar tune or song may cause interference at the phonological level due to the arousal of memories that a familiar song invokes. For example, when one hears an instrumental song that sounds familiar, this could intensify affect due to remembered lyrics or recalled memories having to do with the particular song. Finally, the Mozart effect (Wilding, Mohindra, & Breen-Lewis, 1982) has been shown to increase memory retention in some studies but other researchers failed to find an effect (Steele, 2003). The focus in the present study is not on how music affects memory but more specifically on how certain types of music might cause more interference with the PL in WM, disrupting ability to recall semantic information from LTM.

Extending the Previous Research

Previous research by Alley and Green (2008) is the most relevant to this study and the specific hypotheses. Alley and Green (2008) used a within-subjects design with two different popular songs that were reported as "familiar to most college students" (p. 282) at the time. The present research used a between-subjects design to eliminate the carryover effects that occur with the use of a within-subjects design. The song being used was unfamiliar to most, if not all, of the students in the sample which will ensure the changes in the dependent variables will be solely due to the lyrics in music. The lyrics in the music should deplete resources from the PL and restrict access of phonologically coded information from passing from the PL to LTM. Finally, the dependent variable in the present research is a memory task that requires access to LTM for

retrieval of target stimuli, unlike that of previous researchers who used WM tasks as a dependent variable (Alley & Green, 2008; Iwanga & Ito, 2002).

All of the previously mentioned effects were taken into account when the methodology was developed for this research. This study included words in the encoding task that are considered medium in length (i.e. *controlled*) and that are phonemically different. The present study used music that was acoustically identical in the lyric and no-lyric conditions and that was unfamiliar to participants. Participants were asked to recall words from the original list, and, of the words recalled, they were asked to rank how confident they were that each recalled word was on the original list of words. Participants were also asked if what they listened to was familiar, and if they enjoyed what they listened to (instrumental music, lyrical music, or white noise/nature sounds). Actual memory performance is also an important outcome variable that will determine if lyrics hinder semantic memory performance. Taken together, all of the modifications and additions to the methodology will provide useful information about metacognitive judgments that lyrics in music inhibit one's ability to remember a list of words as well as whether or not the lyrics in music affect LTM performance.

CHAPTER 3

METHODOLOGY

Participants

All participants in this study were volunteer students from a mid-sized mid-western university. Participants signed up to participate in the study through the use of SONA, an online research study coordinating system used at many universities. Participants earned credits that could be applied toward course credit at the discretion of the course instructor. The study sample consisted of a total of 59 participants. An initial power analysis was performed to estimate the sample size needed to detect an effect size of 0.4 with a power of 0.8. The effect size of 0.4 was selected because it represented a medium effect size. Previous studies with similar designs did not report specific effect sizes (Alley & Green, 2008; Iwanaga & Ito, 2002; Pring & Walker, 1994). The initial power analysis indicated a total of 64 participants would be needed to achieve a power of 0.8 (Faul, Erdfelder, Lang, & Buchner, 2007; Faul, Erdfelder, Buchner, & Lang, 2009). A post-hoc power analysis was performed in which the total sample size of 59 was entered, along with the effect size of 0.4; results from the post-hoc power analysis showed a power of 0.77 was achieved. There were 48 participants that were between the ages of 18 and 22 years old and the remaining 11 participants ranged in age from 23 to 50 years old for a total of 59 participants with a mean age of 21.6 (SD=5.2) . There were 15 male and 44 female participants, of which, 48 participants reported a Caucasian ethnicity, seven participants reported an African American ethnicity, and four participants reported mixed ethnicities.

Materials

A list of 16 words (Appendix A) were randomly selected from the Medical Research Council psycholinguistic database (Coltheart, 1981) were given to participants on a piece of

paper for a designated time limit. The words were all nouns, ranging from five to 11 letters, with a frequency range of 40-100 appearances per 1,000,000. A forgetting task was also given to all participants on separate sheets of paper; the paper consisted of simple math problems (Appendix B) and a maze (Scratch.mit.edu) (Appendix C). Participants wrote down words they remembered from the original list of words and gave each remembered word a confidence rating (Appendix F). Participants also completed a simple demographics survey of three questions after the encoding and forgetting tasks were completed (see Appendix D). The list of words was given to all participants for exactly one minute. Universal headphones, which go over the ears and were plugged into the researcher-run computer, were supplied to participants in order to listen to music or nature sounds. Two versions of the folk song "Fare Thee Well, Joshua" were used; one version had lyrics and the other did not have lyrics. Both versions of the song, one with and one without lyrics, started playing at the 0:23 mark and played for one minute. Participants in the control condition listened to running water for one minute. All three audio clips were accessed through YouTube; researchers ensured that the target audio clip was the only audio coming from the headphones (i.e., not an ad on YouTube). Researchers made a final check of the audio level ensuring that the YouTube audio was turned all the way up and that the computer volume was set at 64. All participants completed a final questionnaire of metacognitive questions (Appendix E).

Procedure

Participants arrived at the research room, sat down, and reviewed a consent form while listening to the researcher explain the study. Participants were then asked to sign a copy of the consent form and were encouraged to keep another copy of the consent form for their records; the researcher then answered any questions that participants had before beginning the

experiment. After the researcher collected the signed consent form, participants were randomly assigned to the control condition, the instrumental music condition, or the music with lyrics condition.

After random assignment to conditions, participants were instructed to, "remember as many words as you can from this list, you will be asked to later report the words on this list;" this was the encoding task. After instructions on the encoding task were given, participants were then presented a list of 16 words for one minute. The encoding task was the same for each condition; the same list of words were used for each condition, all of the words on the list were presented at the same time, and the list was available for all participants to study for the same allotted time of one minute. All participants were sitting at a desk in the research room while the researcher explained the procedure of the study. Furthermore, the researcher informed all participants multiple times that they had an allotted time of one minute to read and try to remember the list of words given to them. The list of words appeared on a laminated piece of paper that was flipped upside down, not visible to participants, until participants heard all the instructions from the researcher. Once the researcher was finished explaining the procedure to the participants, participants then flipped the laminated list of words over, exposing the word list to participants for one minute before the researcher removed the list of words from all participants. The list of words was then stored in a location that was out of sight from all participants.

Participants in the control condition listened to natural sounds (running water) during the encoding task. Participants in the instrumental music condition listened to "Fare Thee Well, Joshua" without the lyrics during the encoding task; researchers started playing the song at the 0:23 mark and the song played for one minute during the encoding task. Participants in the

music with lyrics condition listened to the same part of the same song with lyrics for one minute while encoding the list of words.

After the one-minute mark of the encoding task, the list of words that all participants were studying was taken from them, the music stopped playing for the experimental groups, and the nature sounds stopped playing for the control condition. Participants were then instructed to complete a forgetting task which was designed to ensure that participants were not rehearsing the words from the encoding task. The forgetting task lasted three minutes and was comprised of simple math problems and a maze. Participants attempted to complete a maze, in pen, which was printed out and given to them; all participants had up to 90 seconds to complete the maze. Participants were then instructed to "please take your time and complete the maze to the best of your ability, if you make a mistake, you can start over with a different colored pen. You will have 90 seconds to complete the maze, if you finish early, you may start the math problems early. You will also have 90 seconds to complete as many of the math problems that you can, please perform to the best of your ability on each task." The researcher answered all questions that participants had before initiating participants on the forgetting task.

After 90 seconds, the maze was removed from sight, and the participants were given a front-and-back sheet of paper with math problems on it. The pens, for the maze and the math problems, along with the flipped-over consent form were the only things on the table during the experiment. After 90 seconds of completing simple math problems, the researcher instructed the participants to stop, and the researcher removed the math problems from sight. Each group of participants in the three conditions was instructed to complete each part of the forgetting task until notification and instruction from the researcher; the forgetting task was discontinued after three minutes for each participant. The forgetting tasks were always presented to participants in

the same order, that is, the maze for the first minute and a half, then math problems for the last minute and a half.

After the three-minute mark of the forgetting task, the researcher instructed all participants "please try to recall words from the original list, you may write them on the left side of the piece of paper that I give you. Please completely ignore the right side of this paper for now, please just report any words you remember from the original list of words on the blank lines on the left; you have one minute to do so." The researcher positioned the recall sheet to be directly in front of the participant; however, the recall sheet was flipped over in order for the researcher to have the opportunity to explain the entire procedure before the participant began. Furthermore, an example recall sheet, identical to the sheet the participant was about to write their remembered words on, was used to explain the word-recall procedure. The example recall sheet had words on it such as "Word," "recall," and "sheet" that were selected specifically to ensure that there was going to be no interference from words other than the words on the original list and those words on the title of the recall sheet (see appendix F). After a final reminder from the researcher that the participant had one minute to recall words they may remember from the original list, all participants completed the recall task.

After all participants were given one minute to recall and write down words they remembered from the original list, they were informed and given instructions regarding the confidence ratings of those remembered words. Before instructions were given on the confidence rating procedure, participants were informed, "you may no longer report any remembered words from the original list, any word you report from this moment on will not be included." Instructions given to participants regarding the rating procedure of previously recalled words were "now give each word that you recalled a 'confidence rating', for instance,

some words you may have recalled seem to stand out more than others, and you are more confident that these words were on the original list when compared to other words you recalled. The more confident you are that a word was on the original list, the higher rating you give that word; please mark a 'dash' on the provided line for each remembered word." An 80mm visual analog scale (VAS) was used by each participant to rank the confidence of each recalled word. The VAS read "Not at all confident" above the far left side of the line, and above the far right side of the line read "Very confident" in regard to participant confidence that the recalled word was on the original list of words. Participants viewed the example recall sheet once again, were given an explanation of the recall rating procedure until they understood it, before giving each remembered word a confidence rating. All participants had up to one minute to give each remembered word a confidence rating. The number of correctly reported words was the operational definition of word recall. The mean confidence rating of correctly reported words was the operational definition of confidence rating of correctly recalled words.

After the recall and rating of each remembered word, the researcher gave participants a demographic survey that asked about gender, age, and ethnicity. Once the demographic survey was completed, participants were then given another questionnaire with metacognitive questions asking whether or not they enjoyed what they listened to, what their favorite music genre was, and whether or not they remembered any lyrics from the song, if they happened to hear a song with lyrics. After participants completed the demographic and metacognitive questionnaires, they were then verbally debriefed. Participants were told, "Thank you for your participation in this study. The purpose of this study was to investigate factors that affect your ability to recall words from a list. In other words, we are interested in factors that affect your ability to learn and recall information." Participants were then asked if they have any questions about the study.

Participants were reminded that they could keep the unsigned copy of the informed consent form, which had the researchers contact information on it if they happen to have any future questions about their participation. Lastly, the researcher thanked all participants for their participation, as the participants were dismissed.

Planned Analysis

Planned contrasts compared the three conditions on both number of words recalled and confidence ratings of those correctly recalled words. The researcher also ran ANOVAs in order to compare the overall number of words recalled and the overall recall confidence ratings of the correctly recalled words between the three groups. The assumptions of ANOVA include: interval/ratio data, independent observations, normal distribution or large sample size, homogeneity of variance, and random sampling. A further description of each assumption will follow in the results chapter. The first and second assumptions were met because each participant, or data point, was independent of one another and interval in nature. The third and fourth assumptions were met because there were approximately 20 participants in each condition. The fifth assumption was met due to the fact that participants were randomly selected to a condition; however, participants were not selected at random – participants self-selected to participate in the study – therefore, generalizability to the population is questionable. Descriptive statistics were also reported in addition to the tests of significance and effect size.

Hypothesis 1a

The first contrast compared the number of words correctly recalled in the control condition to the instrumental music and music with lyrics conditions. Participants in the control condition, who listened to running water and natural noises during the encoding task, were

hypothesized to correctly recall significantly more words compared to participants in the two experimental conditions.

Hypothesis 1b

The first contrast also compared the recall confidence ratings of correctly recalled words between the control condition and the instrumental music and the music with lyrics conditions. Participants in the control condition were hypothesized to report a significantly higher confidence rating of the correctly recalled words compared to the participants in the two experimental conditions.

Hypothesis 2a

The second contrast compared the number of words correctly recalled between the music with lyrics condition and the instrumental music condition. Participants in the instrumental music condition, who listened to music without lyrics during the encoding task, were hypothesized to correctly recall significantly more words than participants in the music with lyrics condition.

Hypothesis 2b

The second contrast also compared the participant recall confidence ratings of correctly recalled words in the music with lyrics condition and the instrumental music condition. Participants in the instrumental music condition were hypothesized to report a significantly higher confidence rating on the correctly recalled words compared to the participants in the music with lyrics condition.

CHAPTER FOUR

RESULTS

This chapter reviews the results from conducted ANOVAs in order to compare the overall number of correct words recalled and overall recall confidence ratings on correctly recalled words between the groups. Before discussing ANOVA results, a synopsis of the assumptions regarding the ANOVA will be discussed. Further, planned contrasts are presented and described after the results of each ANOVA. Finally, the results chapter concludes with supplemental analyses of information gathered from participants during the experiment.

Correct Words Recalled

The assumptions of an ANOVA include: independent observations, interval/ratio data, normal distribution or large sample size, homogeneity of variance, and random sampling. The following is a description of each ANOVA assumption for the first ANOVA comparing mean correct words recalled between groups. The first assumption was met because each participant or data point was independent of the others. For example, each participant was randomly assigned to a condition before beginning the experiment; participants volunteered in the experiment one at a time in the same research setting. The second assumption regarding interval/ratio data was met because number of words recalled is a ratio level variable. SPSS was used in order to investigate whether or not the distribution on number of words recalled correctly was normal (assumption three). An analysis revealed that the population was not normal; Shapiro-Wilks revealed a significant difference from normality, $W(59)= .947$, $p= .013$. However, the data were robust to this assumption due to the large sample size (n=59), which was greater than 30 (Field, 2013). Levines test of homogeneity of variance was not significant, $F(2,56)= .368$, $p =.694$, indicating that the variance within each condition was about equal

(assumption four). The fifth assumption was met due to the fact that participants were randomly selected to a condition; however, participants were not selected at random – participants self-selected to participate in the study – therefore, generalizability to the population is questionable and will be further discussed in the discussion chapter.

A one-way between subjects ANOVA revealed a nonsignificant difference on correctly recalled words across the control condition (*M*=4.45, *SD*= 2.06), instrumental music condition (*M*= 4.83, *SD*= 2.06), and the music with lyrics condition (*M*= 3.63, *SD*= 1.82), *F* (2,56)= 1.724, *p* =.188. Means for the conditions are displayed in Figure 1.

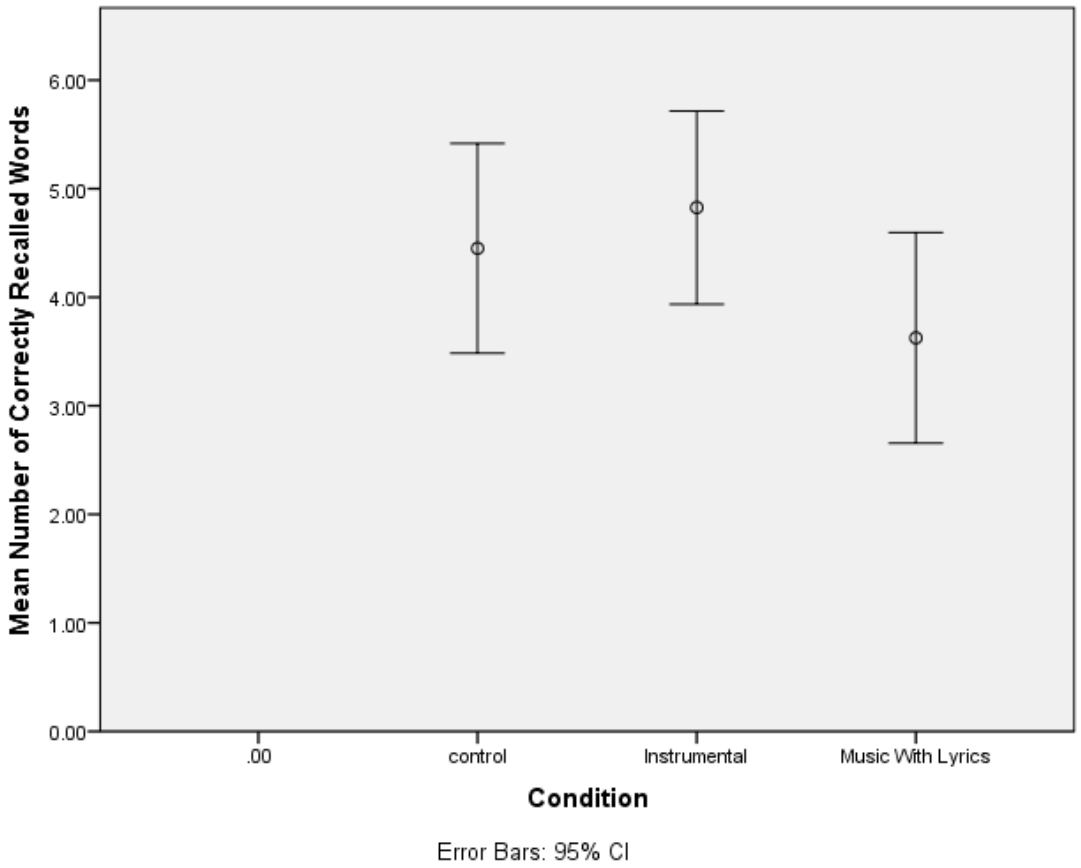

Figure 1. Mean value of correctly recalled words for each condition. No significant difference of correctly recalled words was found between the conditions.

Numerically, participants recalled the most words in the instrumental music condition, although this difference was nonsignificant.

The assumptions of the planned contrasts are the same as the previously mentioned ANOVA assumptions; all of the assumptions for the planned contrasts were met. The first contrast was performed in order to examine the differences between the control (running-water) and the two music conditions (one with lyrics and the other without) regarding participants' ability to recall words from the original list and the differences in recall confidence. The second contrast was established to compare words correctly recalled and the confidence ratings of those correctly recalled words between the instrumental music condition and the music with lyrics condition. See Table 1 for a depiction of the two planned contrasts.

Table 1. *Weights for the Two Planned Contrasts.*

	Condition		
Contrast	Control	Instrumental	Music With Lyrics
1	-2	1	1
2	0	-1	1

The first contrast revealed a nonsignificant difference between the control condition and the two music conditions on the dependent variable of correctly recalled words, t (56) = -.406, p =.686. The second contrast comparing correctly recalled words between the two music groups was nonsignificant; however, it was approaching significance, t (56)= -1.845, p =.07.

Confidence Rating of Correctly Recalled Words

The following paragraph will discuss the assumptions of the ANOVA that investigated differences between the conditions in regard to confidence ratings of correctly recalled words.

Again, the assumptions of an ANOVA include: independent observations, interval/ratio data, normal distribution or large sample size, homogeneity of variance, and random sampling. The first assumption was met because each participant or data point was independent of one another (i.e. each participant was run one at a time in a randomly selected condition). The second assumption regarding interval/ratio data was met because participants were instructed to indicate with a dash (/) on a visual analog scale (VAS) how confident they were that the word they recalled was on the original list. Scoring of the VAS was done by measuring, in millimeters, the location on the VAS where the participant placed the dash. The measurement of this confidence rating was from the left hash on the VAS to where the mark was placed (higher measurements in mm indicate higher confidence). Furthermore, the dependent variable of confidence rating required participants to recalled at least one correct word from the original list. In other words, if a participant recalled five words, none of which were on the original list, there would be no data point for a comparison to a different condition. The dependent variable of confidence rating is interval data because a participant could indicate that they were not at all confident that the word they recalled was on the original list (measured as 0mm of the total 80mm VAS). An analysis revealed that the distribution of confidence ratings was not normal; Shapiro-Wilks revealed a significant difference from normality, $W(59)= .688$, $p<. 001$. However, the data were robust to this third assumption due to the large sample size (n=59), which is greater than 30. Levene's test of homogeneity of variance (assumption four) was not significant, $F(2,56)= .417$, $p =.661$, indicating that the variance among conditions can be considered equal. Finally, the fifth assumption was met due to the fact that participants were randomly selected to a condition; however, participants were not selected at random – participants self-selected to participate in the

study – therefore, generalizability to the population is questionable and will be further discussed in the discussion chapter.

The second ANOVA revealed a nonsignificant difference on confidence ratings of correctly recalled words between the control condition (*M*= 71.85, *SD*= 13.47), the instrumental music condition (*M*= 70.83, *SD*= 11.89), and the music with lyrics condition (*M*= 69.56, *SD*= 17.43), *F* (2,56)= .118, *p* = .889. Figure 2 depicts the mean confidence ratings of correctly recalled words for each condition.

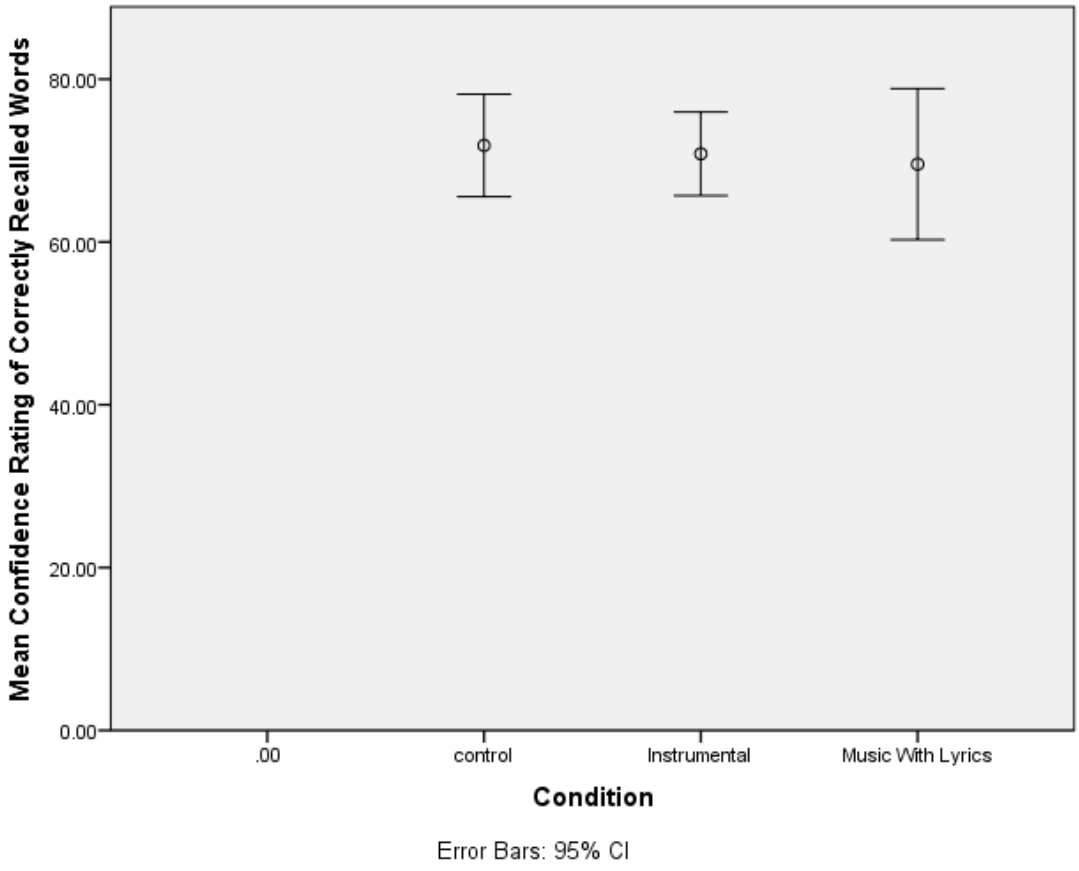

Figure 2. Mean value of the confidence ratings of correctly recalled words for each condition. There was no significant difference between the three groups.

As shown in Figure 2, the pattern of results was consistent with the hypothesis that the control condition would have the highest confidence ratings of correctly recalled words and the instrumental music condition would have the next highest confidence ratings of correctly recalled words; however, the difference between the groups failed to reach significance. The first contrast, in regard to the second dependent variable of correctly recalled word confidence ratings, revealed a nonsignificant result, t (56) = -.425, p =.672. Furthermore, the second contrast also revealed a nonsignificant result when the two music conditions were being compared on their confidence ratings of correctly recalled words, t(56) =.425, p =.672. Although the planned contrast model failed to reveal a significant difference between the conditions, there were several interesting supplemental findings that will be discussed in the final section of this results chapter.

Supplemental Analyses

This final section of the results chapter will review supplemental analyses in order to determine what, if any, effect the independent variable had on additional performance measures (e.g., number of incorrectly recalled words) and responses to metacognitive questions (e.g., enjoyment of the audio clip). There were four additional variables that were of interest to the researcher: total words recalled, incorrectly recalled words, incorrectly recalled word confidence ratings, and responses as to whether the participants enjoyed what they heard.

Total words recalled.

Participants in the control condition (M =4.90, SD = 1.92) reported slightly more total words on average compared to the music with lyrics condition (M = 4.56, SD =1.79), and participants in the instrumental music condition (M = 6.04, SD = 1.92) reported more total words on average than participants in the other two conditions. Further, ANOVA results revealed that

there was a significant difference among the three conditions regarding the total number of words recalled by participants, $F(2,56)=3.45$, $p= .039$, $\eta^2=.11$. The second planned contrast comparing the instrumental music group to the music with lyrics group revealed a significant difference between these two groups, t (56)= -2.415, p =.019. The first contrast comparing the control condition to the two music conditions on total words recalled was not significant, t (56)= .774, p =.442. Figure 3 depicts the mean number of total words recalled for each condition.

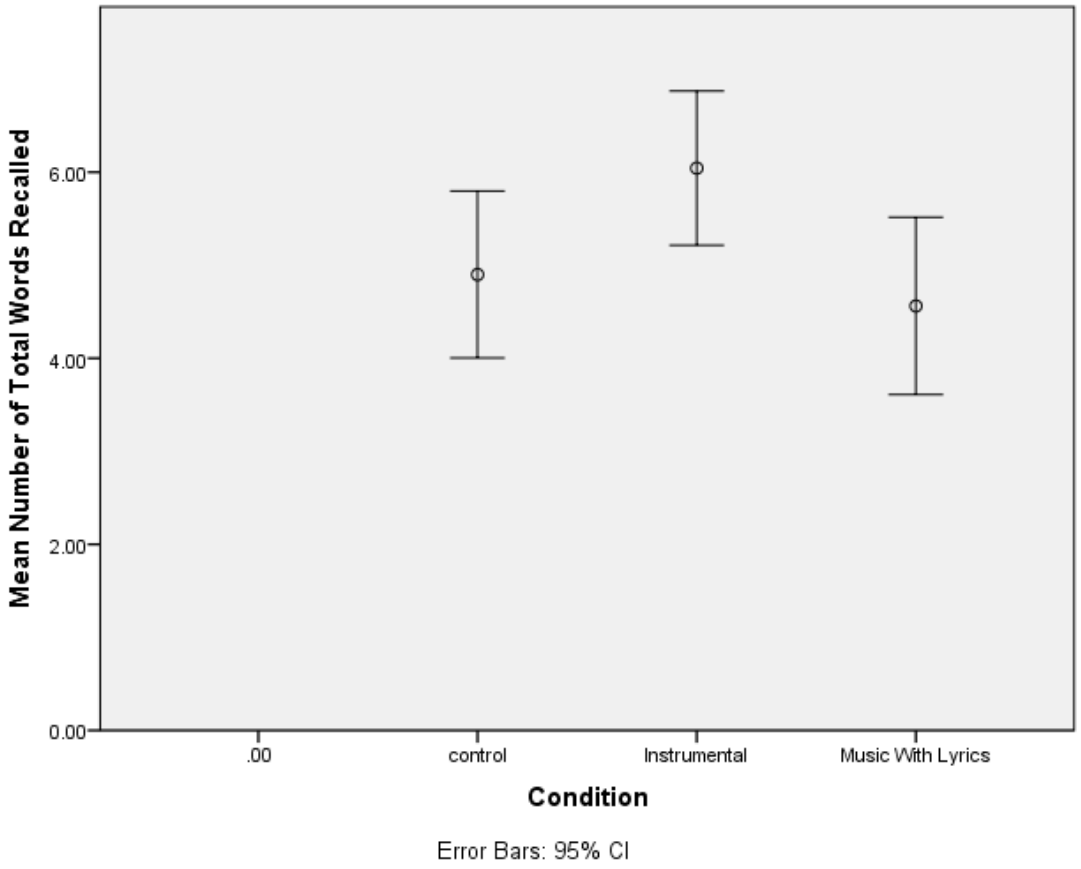

Figure 3. Mean value of the total words reported for each condition. There was a significant difference found between the three groups.

Incorrectly recalled words.

Participants in the control condition (M =.45, SD =.60) reported the fewest incorrect words. Participants in the music with lyrics condition (M =.94, SD = 1.48) reported slightly

more incorrect words, and participants in the instrumental music condition (*M* =1.22, *SD* =1.48) reported the most incorrect words. Additionally, ANOVA results revealed that there was no significant difference among the three groups regarding the number of incorrectly recalled words, *F* (2,56)= 2.03, *p* =.141. Further, planned contrasts revealed no significant differences on the mean of incorrectly recalled words between the control condition and the two music conditions (contrast one), *t*(56)= 1.812, *p*=.075; there was no significant difference between the two music conditions in regard to the mean of incorrectly recalled words, *t*(56)= -.687, *p*=.495. Figure 4 depicts the mean number of incorrectly recalled words for each condition.

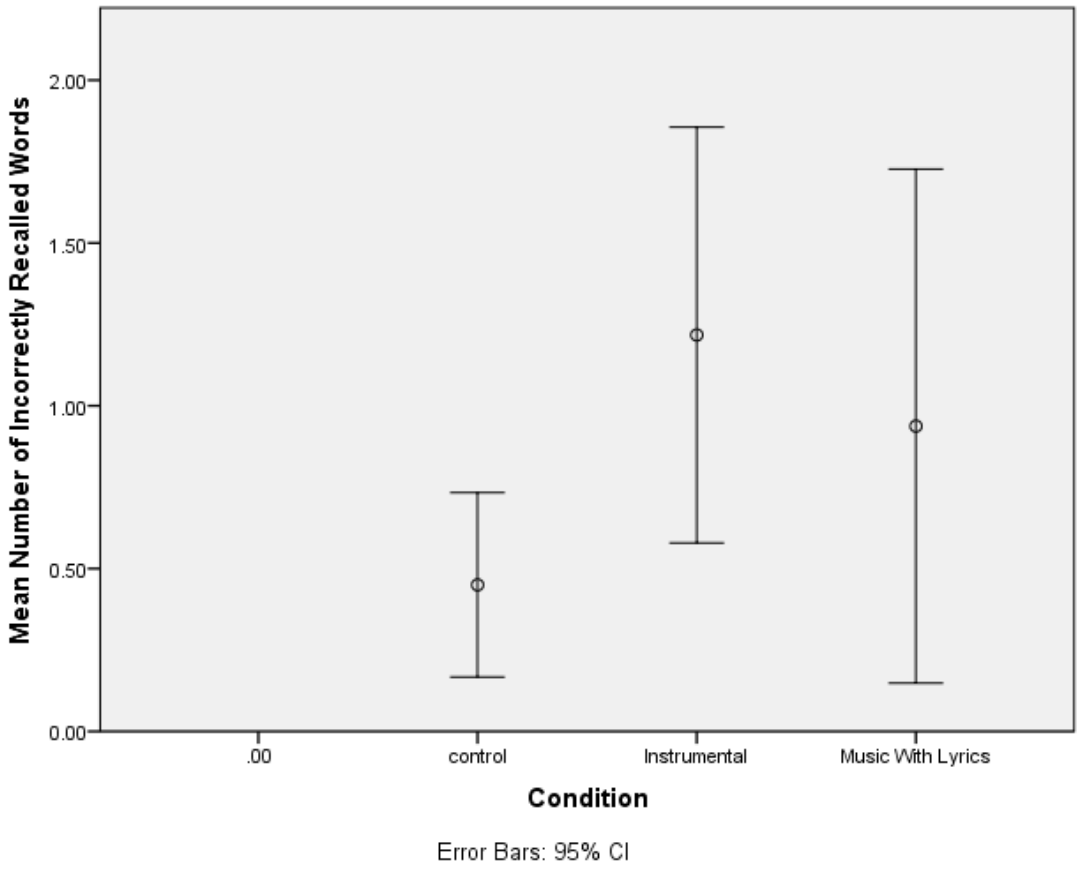

Figure 4. Mean value of the incorrectly recalled words reported for each condition. There was no significant difference found between the three groups.

Incorrectly recalled word confidence rating

Participants in the control condition had the lowest confidence rating for incorrectly recalled words (*M*= 19.00, *SD*= 21.41). Participants in the music with lyrics condition had the next highest confidence rating for incorrectly recalled words (*M*= 22.48 *SD* = 25.43), and participants in the instrumental music condition had the highest mean confidence rating for incorrectly recalled words (*M*= 30.90, *SD* =18.91). ANOVA results revealed no significant difference of confidence ratings of incorrectly recalled words among the three groups, $F(2,24)= .862$, $p= .435$. The first planned contrast comparing the control condition to the two music conditions on the confidence ratings of incorrectly recalled words revealed no significant difference, $t(24)= .843$, $p= .407$. The second planned contrast comparing the instrumental music condition to the music with lyrics condition revealed no significant difference, $t(24)= .-.806$, $p =.428$. Figure 5 below depicts the mean confidence rating for incorrectly recalled words for each condition.

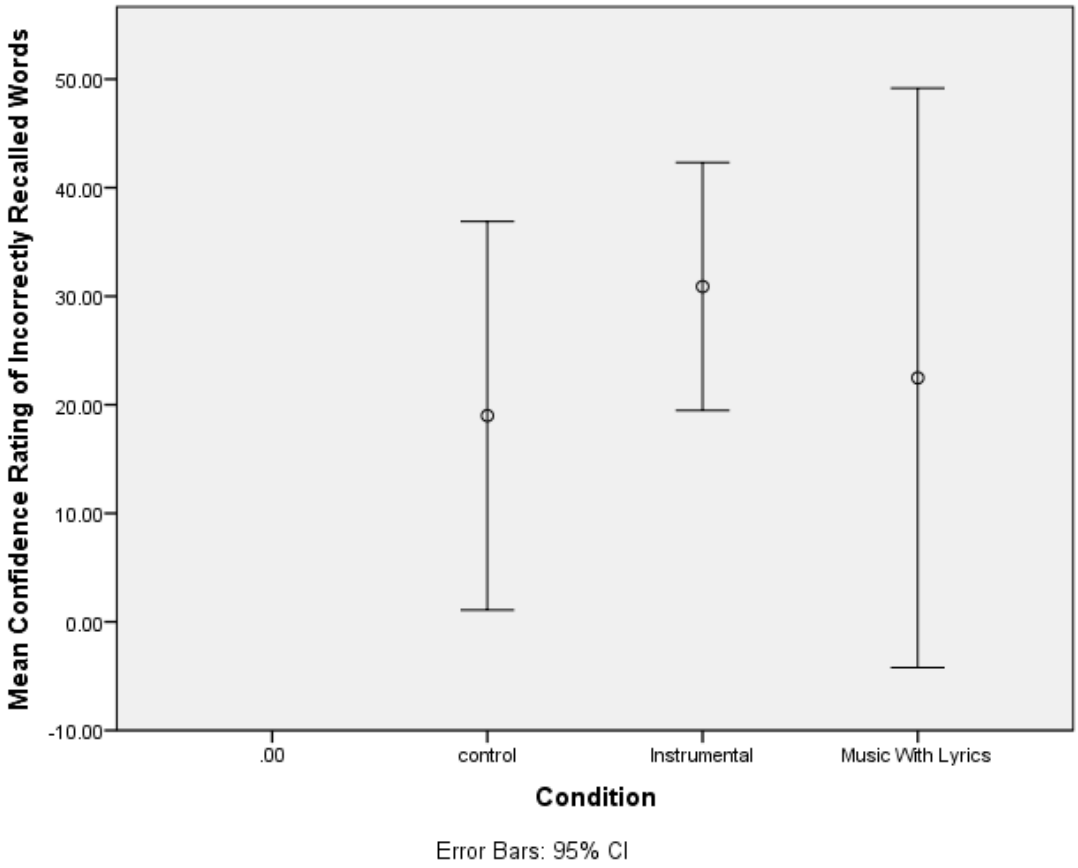

Figure 5. Mean confidence rating number of incorrectly recalled words. There was no significant difference between the conditions.

Enjoyment of sound clip

Participants in the control condition (*M*= 1.70, *SD*=.47), who listened to the running-water audio clip, reported enjoying what they heard more compared to the instrumental music condition (*M*=1.57, *SD*=.59), and the music with lyrics condition (*M*=1.19, *SD*=.83). A Kruskal-Wallis ANOVA was computed because the type of data for this dependent variable (enjoyment of music) was ordinal in nature, therefore it did not meet the assumption for an ANOVA. The Kruskal-Wallis showed no significant difference in responses to the "did you enjoy what you heard?" question across the three conditions, $\chi^2(2)= 4.19$, $p=.123$. Figure 6 below depicts the mean enjoyment ratings of each condition.

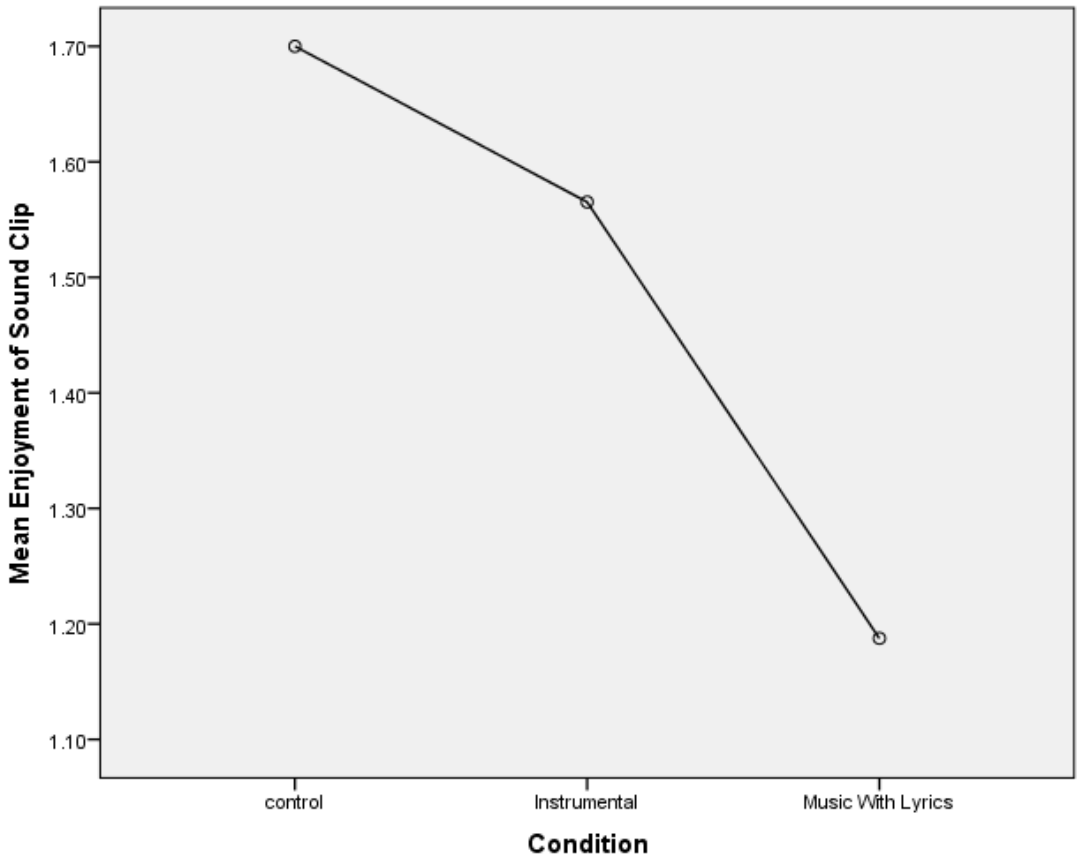

Figure 6. Mean enjoyment ratings of each condition (0 indicates no enjoyment; 1 indicates neutral enjoyment; 2 indicates high enjoyment). There was no significant difference between conditions.

CHAPTER FIVE

DISCUSSION

This final chapter discusses the significant and nonsignificant findings from the results chapter. This section also reviews possible explanations for the results. This chapter reviews the implications for the WM model, discusses study habits for students, and concludes with proposals for future research in this field.

Hypothesis 1a

Hypothesis 1a stated that participants in the control condition, who listened to running water and natural noises during the encoding task, would correctly recall significantly more words compared to participants in the two experimental conditions. The rationale for the hypotheses came from studies such as Pring and Walker (1994) which found that memories of unvocalized nursery rhymes impeded performance in memory recall. Additionally, Rauscher, Shaw, and Ky (1995) revealed that intensified affect increased memory performance in spatial memory tasks while Iwanga and Ito (2002) reported that their sample showed a disturbance in memory performance in a verbal WM task under a music with lyrics and a music without lyrics condition. The study by Iwanga and Ito (2002) is comparable to the present study in that participants from their sample in the music with lyrics condition reported the highest perceived disturbance on the verbal WM task. Another study (Alley & Green, 2008) assessing WM and audio with lyrics revealed that four of four participant groups ranked their performance being best in a silent condition, then an instrumental music condition, followed by an irrelevant speech condition, and finally a lyrical music condition. These previous studies help support a rationale as to why listening to lyrics in music may be detrimental while studying important material. In the present study, the first contrast compared the number of words correctly recalled in the

control condition to the number of correctly recalled words in the music with lyrics and music without lyrics conditions. Contrary to findings from previous research, participants in the control condition did not recall significantly more words than the participants in the two music conditions.

Hypothesis 1b

The first contrast also compared the recall confidence ratings of correctly recalled words between the control condition, and the instrumental music and the music with lyrics conditions. Participants were required to give confidence ratings of the words they recalled from the original list of words; this is considered a metacognitive judgment. Previous research has shown that there is a strong correlation between participants' metacognitive judgments of their performance and their actual performance (Maki et al., 2005; Weil et al., 2013); Alley and Green (2008) demonstrated this when they found that participants' ratings of their performance on a memory task in four different conditions matched their actual memory performance in each condition. In the present study, participants in the control condition did not report a significantly higher confidence rating of correctly recalled words compared to participants in the two music conditions.

Hypothesis 2a

The second contrast compared the number of words correctly recalled between the music with lyrics condition and the instrumental music condition. Participants in the instrumental music condition did not recall significantly more words than participants in the music with lyrics. This finding was marginally significant, but is unclear whether there is a real difference that could not be detected in the present study or if there truly is not a difference; sample power and effect size will be discussed in a later section of this chapter.

Hypothesis 2b

The second contrast also compared the recall confidence ratings of correctly recalled words of participants in the music with lyrics condition and participants in the instrumental music condition. Participants in the instrumental music condition did not report a significantly higher confidence rating on the correctly recalled words compared to the participants in the music with lyrics condition.

Possible Explanations of Nonsignificant Findings

Power and effect size.

The most obvious explanation for the null findings from this research is that of the power. The power analysis, based on an effect size of .4 and power of .8, determined an actual power of .802 with a sample size of 64 participants. With a target of a smaller effect size (i.e. .25, which is considered medium) and larger sample, it is possible that the results relevant to one or more of the hypotheses would have been found to be significant. However, due to the lack of time and participants, the researcher decided to continue with the analysis with the sample size of 59 participants. Further, a post hoc power analysis showed that the power achieved with the 59 participants in the data analysis, and the effect size of .4, was .77. Finally, there could be an effect of lyrics in music and memory performance, but with a smaller effect size than anticipated; more research is needed in order to determine whether this is the case.

Participant encoding and retrieval styles.

Data regarding the type of encoding and retrieval strategy that participants used during the encoding task was not collected. For example, participants could have "chunked" the words into three or four four-word "blocks" based on the phonemes, look, or meaning of the words in order to better remember as many of the words on the list. Further, participants could have

created a story with the different types of words, incorporating each word into the story and allowing for the story to be easier rehearsed than each word independently. Data on the type of style used by participants during encoding and retrieval could be an important factor to be considered in this type of research. In other words, encoding in a certain style may allow for easier rehearsal of a list of words, and may result in easier retrieval; future studies on semantic memory should include encoding and retrieval strategies as additional factors. Finally, encoding and retrieval in the same style has been shown to improve performance, also known as encoding specificity (Tulving & Thomson, 1973; Craik & Tulving, 1975), similar to how learning and testing in the same environment has shown to improve performance, also known as cued recall (Tulving & Pearlstone, 1966). Lastly, it is important to collect data from participants on how they encode information, encoding specificity, and how they retrieve that encoded information, cued recall, in order to more accurately measure the effects of factors like the presence of music and lyrics.

Forgetting task.

LTM is defined as anything longer than 30 seconds (Goldstein, 2013); therefore, the three minute forgetting task was created in order to establish the word list that participants were tasked with remembering as a LTM task. Furthermore, the design of the forgetting task was also created to allow participants to use their WM in order to complete the maze (i.e. using their Visuospatial sketchpad component of the WM model) and math problems without introducing stimuli that interfered with the PL (phonological loop). The forgetting task was successful in not introducing stimuli that interfered with the PL; however, the length of the forgetting task may be an issue. For instance, the mean number of words correctly recalled by participants was 4.37 out of 16 total words on the original word list. This suggests that the forgetting task may have been too

long, due to the fact that, on average, participants recalled just over a quarter of the words on the original list. Future directions that studies such as this should consider would be using a shorter forgetting task without introducing any stimuli that may interfere with the PL.

Audio selection.

An ANOVA revealed that there was a marginally significant difference between the three participant conditions on participants' reported enjoyment of the audio clip that they heard, $F(2,56)= 3.1$, $p =.054$. Again, this question was asked in order to better determine whether or not positive affect plays a role in improving memory performance. Although the audio clips were not pilot tested for enjoyment, a discussion involving which audio clips to include in the study took place; the final decision of having the running water as a condition along with the selected song, with and without audio, was made and agreed upon by the researcher and all committee members. A study by Rauscher, Shaw and Ky (1995) revealed that intensified affect increased memory performance in spatial memory tasks. Participants in the control condition, who listened to running water during the encoding task, reported enjoying what they heard more when compared to the other two groups; however; the difference in enjoyment of the audio clip between conditions was nonsignificant. It is important to note, however, that participants reported the highest enjoyment ratings of what they heard in the control condition. In contrast, the control condition did not produce the highest word-recall performances of participants; it was the instrumental music condition that revealed the best correct word-recall performance of participants.

This variable may still be of value to researchers investigating memory, as the 'enjoy sound' question reveals to researchers what it is that participants enjoy listening to, which may or may not be similar to what other individuals in the population listen to while studying for an

exam or preparing for a business meeting. Finally, participants in the music with lyrics condition reported 'no' to the "did you enjoy what you heard?" question more often than participants in the other two conditions. It is unknown whether or not participants know that lyrics in music may hinder their memory performance; however, what is known is that, within this sample, participants reported enjoying the music with lyrics condition least compared to the instrumental and control conditions. This could have been because the music was unfamiliar to the participants and the song was not a part of most participants' preferred music genre.

In regard to music selection, the specific song used in this study (*Fare Thee Well, Joshua*) was selected in order to minimize the chances of participants ever having heard the song before. However, participants were not asked whether or not they have heard the song before. Participants who have never heard a song most likely do not have an emotional connection to the beat, tempo, or lyrics. A final selection criteria of the song used in the study was that of its tempo; the song has a medium tempo and beat and is not likely to increase positive affect. Finally, the fact that more participants in the control condition reported enjoying what they heard more compared to the two musical conditions allows one to infer that the "neutral" control condition of running water may be more pleasant and positively charged than the song selected for the study; future researchers should consider what they use for a control condition and consider whether or not it is going to be perceived as neutral to the listener.

Limitations and Future Research Directions

An ANOVA has five assumptions, the fifth being that of random sampling. Previous chapters mentioned that all five assumptions were met except that participants were not selected at random; instead, they self-selected to participate in the study through the use of SONA, a

popular online research coordinating system. Generalizability of these findings to the general population is highly questionable due to this self-selection.

The sample of participant data that was analyzed came from 59 people, which was less than the recommended number of participants from the initial power analysis with an effect size of .4 and a power of .8. Again, there may be an effect of lyrics on memory; however, a larger sample size with stricter experimental procedures would allow a more promising opportunity for a smaller effect to be detected.

The previously mentioned audio selections of stimuli in the experiment (running water, instrumental music, and music with lyrics) showed that participants enjoyed listening to running water more than instrumental folk music, and participants enjoyed instrumental folk music more than folk music with lyrics included. A re-evaluation of the selection of musical stimuli along with the selection of the control stimuli is suggested for future research in this area.

Data on overall perceived performance between participants in the three conditions was not collected. For example, the current study failed to assess whether participants felt that the encoding task was difficult, and did not assess the differences of perceived difficulty between conditions. Future researchers should include overall perceived difficulty of the encoding task as a variable of interest.

There were a total of two research assistants (RA) and the head researcher who collected data for this study. Both RA's were well-trained in the procedure and the conceptualization of the study before beginning data collection. Both research assistants ran through the procedure twice with the lead-researcher observing the interaction of the research assistants and the participants; there were minor suggestions given to each research assistant before they started collecting data on their own. Although all researchers fully understood the procedure, the researchers

had slight variations in their instructions to participants regarding the encoding task. The encoding task required participants to read and attempt to remember a list of words while listening to one of three audio clips. One researcher gave instructions for the encoding task to participants in a concise but manner but not necessarily as descriptive as it could have been. Moreover, another researcher stated, "you may use whatever memory-tricks that you think you may have to remember these words, such as: chunking, making a story from the words, or rehearsing the words aloud." There was an obvious limitation in the study due to the differences in the instructions given to participants from the researcher regarding the encoding task.

All three researchers also had slight differences in their descriptions of the word recall task and their instructions to participants. For example, during the instructions regarding the word recall procedure, one researcher mentioned to participants, "you may recall any words that you think may have been on the list," and another researcher said, "recall as many words from the original list that you can remember." An ANOVA revealed that the difference in mean number of words correctly recalled across participants tested by the different researchers was nonsignificant, $F(2,56)=2.36$, $p=.103$. In future studies researchers may wish to use a checklist to ensure that every verbal instruction and behavioral example explained to participants is nearly identical.

The procedure of the study was set up in order to minimize confusion of online instructions to participants during the encoding and recall tasks, yet the procedure may have resulted in slight differences in the performances of participants on the word recall task due to varying instructions. Finally, the differences in verbal instructions could be considered a priming effect, which could be controlled for by implementing a checklist with word-for-word instructions to participants.

Implications of Current Research

This research has contributed to the literature by supporting previous research findings and providing results that allow one to question the findings of previous literature as well. For example, results from a study by Iwanga and Ito (2002) revealed that participants performed significantly worse of verbal working memory tasks then they were in the instrumental and lyrics music conditions. However, results from this research revealed, although not significant, the largest difference in performance on correct word recall was between the instrumental music condition and the music with lyrics condition. Moreover, results from this research revealed the largest difference, which was still nonsignificant, between conditions on word recall performance came between the instrumental music condition and the music with lyrics condition. Iwanga and Ito (2002) reported opposite findings in that there was no significant difference in memory performance between participants in the instrumental music and lyrical music conditions.

Due to the fact that results relevant to all four hypotheses were nonsignificant, it is still possible that sounds in the background make a difference, based on the previous literature and the limitations of the present study. Further, lyrics in music were not found to significantly lower LTM performance, nor were they found to significantly decrease perceived memory performance. The differences in results and conclusions between this research and previous research (Iwanga & Ito, 2002; Alley & Green, 2008) suggest that future researchers should modify experimental procedures, include additional variables of interest, and incorporate suggested changes in order to better determine the role that music and lyrics play in semantic memory.

Implications of current research to the WM model.

The results from this study allow one to conclude that lyrics in music may interfere with one's ability to encode and/or retrieve information from LTM, although the difference may not be significant. Perceived memory performance remains to be an important factor within working and long-term memory. The results from the present research may be correct in the sense that there may be no real significant difference between conditions in regard to correct word recall and confidence ratings. Although there was no actual or perceived performance difference found between the conditions, the WM model used to formulate these hypotheses may still be valid. For instance, the PL component of the WM model is comprised of a phonological store, tasked with holding verbal material, and a rehearsal process, tasked with maintaining the decaying verbal material in the PL. It is possible that one of the two subcomponents of the PL does not explain performance differences with experiments using different musical conditions, or, perhaps the rehearsal subcomponent of the PL needs to be further studied. For example, if there was a true difference in correct word recall performance between conditions of instrumental music and lyrical music, the rehearsal subcomponent of the PL would suffer from interference from the lyrics in the music. On the contrary, consider if a person were to listen to two songs during two different encoding tasks, one familiar song with lyrics and the other an unfamiliar instrumental song that was in the person's favorite genre. Would the familiar music with lyrics still deplete the PL? Or would the familiarity of the lyrics in the music result in the PL not being as taxed because the rehearsal subcomponent of the PL does not have to rehearse the already known lyrics? These questions remain to be answered, which is why Baddeley's WM model, and specifically the PL component, merit further investigation.

There are four main components in Baddeley's WM model, all of which interact with each other to process and hold information before transferring that information to LTM or allowing that information to be forgotten. There are two ways in which information could fail to reach LTM: interference with information being processed in the WM model by outside stimuli (commonly known as interference), and failure to rehearse the target stimuli that is being introduced to the WM model (rehearsal failure). Regarding the PL and its relationship with LTM – both interference and rehearsal failure are explained by the two subcomponents of the PL – the model predicted those results; therefore, more research is needed to understand whether the hypothesized effects may be present or not, in which case the model might need further modification.

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Appendix A

List of Words for Encoding Task

Egyptian

Spurred

Polish

Legacy

Scent

Controlled

Fitted

Celebration

Capsule

Collar

Swear

Barley

Uptake

Doorway

Drastic

Stimulation

Appendix B

Stimuli for Attentional Task A

Participants: please answer as many of the following questions that you can in the given time.

There are no variables involved, just simple math problems.

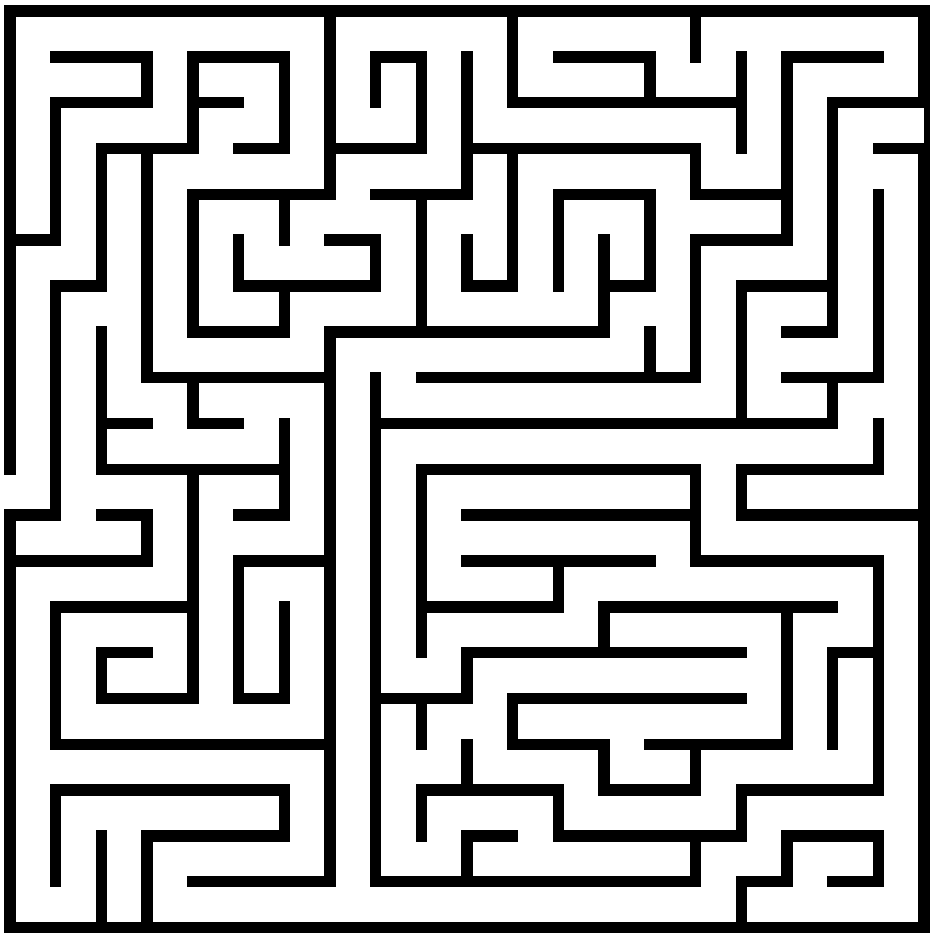
- 2+7=____
- 3x4=____
- 7x6=____
- 9x8=____
- 24/3=____
- 33+24=____
- 22/10=____
- 13+71=____
- 22+13x4=____
- 9-3x4+7=____
- (22-11)/11+3=____
- 14+2/6=____
- 7x3/14=____
- 32/6=____
- 6^3=____
- $(7^2+51)/20$=____
- 17-13+6=____
- 3^4=____
- 4^3=____

- 2^5=____
- 6x12=____
    - 9x11=____
        - 9x10=____
            - 6/4=____
                - 2x3=____
                    - 4+13=____
                        - 11x4=____
                            - 7x3=____
                                - 8/3=____
                            - 5/3=____
                        - 12/3=____
                    - 13/3=____
                - 9.5x2=____
            - 7.8x2=____
        - 3^3=____
    - 4^3=____
- 7^3=____
    - 22/4=____
        - 33/11=____
            - 11^2=____
                - 12x12=____
                    - 12^3=____

Appendix C

Stimulus for Attentional Task B

Participants: Please start the maze on the left, the end is on the right.



Appendix D

Demographics Survey

Please respond to the demographic questions below:

1) Age in Years_____

2) Gender_____

3) Ethnicity_____

Appendix E

Metacognitive Questions

Please answer the questions below:

Did you enjoy what you heard? Y

N

Neutral

*Do you remember any lyrics from the song?(*if you heard lyrics in a song) If so, what are they?

_____

_____

_____

What is your favorite genre of music? *Please circle the corresponding answer.*

Rock	Pop	Rap	Country
Alternative	Folk	Techno	Other_____

Appendix F

Word Recall and Confidence Rating Form

_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]
_____	Not at all confident Very confident [----------]

Not at all confident Very confident

_____ [----------]

Not at all confident Very confident

_____ [----------]