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The Effect of Musical Mnemonics and Musical Training on Word Recall

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THE EFFECT OF MUSICAL MNEMONICS
AND MUSICAL TRAINING ON WORD RECALL

By

Allison M. Pindale

A THESIS

Submitted to the Faculty of
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the requirements for the degree of
Master of Music Therapy

THE EFFECT OF MUSICAL MNEMONICS
AND MUSICAL TRAINING ON WORD RECALL

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The purpose of this study was to examine the interaction effect of musical mnemonics and musical training on word recall in young adults. One hundred University of Miami freshmen participated in this study. Fifty participants were musicians, and the other 50 were non-musicians. The researcher met with each participant one time for 30 minutes. The participants listened to a sung or spoken recording of 14 random words throughout five trials. Verbal recall was measured four times, in which the participants were asked to recall and write down as many words from the presentation as possible.

Results did not reveal significant results in recall scores between musicians and non-musicians, or between musical and spoken rehearsals. The results of this study also did not reveal a significant interaction effect between musical mnemonics and musical training on verbal memory. Therefore, the findings indicate that musical rehearsal is as effective as spoken rehearsal, regardless of musicianship. Moreover, this study revealed significant differences in recall scores across the four recall trials, indicating the role of rehearsal and repetition on verbal learning and recall. Therefore, the rehearsal of verbal material, whether song or spoken, effectively enhances the ability to learn new information.
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Chapter 1

Introduction

Statement of the Problem

Short-term memory (STM) is the temporary storage of newly-learned or acquired information, and is limited in capacity as well as retention duration (Baddeley, 1986; 1992; Gazzaniga, Ivry, & Mangun, 2009). Individuals can typically store approximately seven units, plus or minus two units, of information in STM (Miller, 1956). The information that enters STM only lasts up to several minutes unless it is attended to and encoded through rehearsal processes (Gazzaniga et al., 2009). This limitation in capacity and retention is troublesome, considering the large amount of input individuals receive daily. The ability to transfer sequential verbal information from STM to long-term memory (LTM) is a daily task (Burgess & Hitch, 1999; Martin & Lesch, 1998). Examples of sequential verbal information include phone numbers, addresses, names, list items, directions, academic material, and important dates.

STM includes a subcomponent known as working memory that is responsible for the maintenance and transfer of information into long-term storage. Working memory is comprised of the phonological loop, visuospatial sketchpad, episodic buffer, and central executive (Baddeley, 2000, 2012; Baddeley & Hitch, 1974). Verbal information is processed and encoded in the phonological loop that is responsible for short-term retention of newly-learned words (Baddeley, 1992) and serial order of words (Burgess & Hitch, 1992). The phonological loop maintains verbal information in STM through a phonological store and subvocal articulatory rehearsal mechanism. Verbal information in the phonological store can decay in less than two seconds unless it is rehearsed (Burgess
Large amounts of information enter memory, but only a limited amount is held for further encoding. One way of increasing the amount of information to be retained is by chunking, or the ability to group a large amount of information into smaller units (Miller, 1956). Each unit may contain roughly five to nine items of information, thus increasing the capacity of STM. The ability to learn and maintain a large amount of information is achieved through rehearsal techniques, including mnemonic devices, such as imagery, the link method, peg systems, and method of loci (Roediger, 1980). Other devices such as flash cards, acronyms, and music are used in a repetitive way to help increase the probability of transferring new information into long-term memory.

A substantial amount of literature provides supporting evidence regarding the benefits of using music to improve verbal memory (Jakobson, Lewyscky, Kilgour, & Stoessel, 2008). Several researchers have investigated the positive effect of music as a mnemonic device on verbal memory in typical children (Chazin & Neuschatz, 1990) and adults (Chazin & Neuschatz, 1990; McElhinney & Annett, 1996; Purnell-Webb & Speelman, 2008; Rainey & Larson, 2002; Wallace, 1994).

Other researchers have investigated the positive effect of music as a mnemonic device on verbal memory in clinical populations, such as learning disabilities, multiple sclerosis, and Alzheimer’s disease (Claussen & Thaut, 1997; Gfeller, 1983; Moore, Peterson, O’Shea, McIntosh, & Thaut, 2008; Simmons-Stern, Budson, & Alley, 2010; Thaut, Peterson, Sena, & McIntosh, 2008). Researchers have also investigated the positive effect of music as a mnemonic device on the acquisition of secondary languages in typical populations (Kamahara, 2003; Salcedo, 2010).
Music can be used as a mnemonic device to improve verbal memory because it consists of melodic and rhythmic structures that group a large amount of information into smaller units. The structural elements of rhythm and melody help organize, sequence, and chunk verbal information into meaningful phrases and patterns (Davis, Gfeller, & Thaut, 2008; Dowling, 1973; Wallace, 1994). Additionally, familiar melodies can help improve verbal memory because they provide predictable patterns that serve as a retrieval cue during recall tasks (Rainey & Larsen, 2002).

Another topic of interest among researchers is the effect of musical training, or formal instrumental and/or vocal instruction, on verbal recall. Researchers have found a significant positive effect of musical training on verbal memory in typical children (Ho, Cheung, & Chan, 2003) and adults (Chan, Ho, & Cheung, 1998; Franklin, Moore, Yip, & Jonides, 2008; Jakobson, Lewycky, Kilgour, & Stoesz, 2008; Kilgour, Jakobson, & Cuddy, 2000). The effect of musical training on verbal memory can be explained within the behavioral and neuroanatomical domains.

First, musicians may utilize rehearsal mechanisms that contribute to verbal learning and memory in unique ways (Franklin, Moore, Yip, & Jonides, 2008). These rehearsal mechanisms may enable musicians to encode and retrieve information more efficiently than non-musicians (Jakobson et al., 2008). Second, rehearsal of verbal and tonal information is processed in similar brain regions. Several structures that share similar activations in verbal and tonal rehearsal processes include areas of the prefrontal cortex, auditory cortex, inferior parietal lobe, planum temporale (PT), anterior insula, premotor cortex, and cerebellum (Koelsch, Schulze, Fritz, Müller, & Gruber, 2009).
Last, researchers have found greater left hemispheric activation in structures of musicians compared to non-musicians, including the left PT (Ohnishi et al., 2001; Schlaug, Jäncke, Huang, & Steinmetz, 1995). The left PT is located within Wernicke’s area, which is associated with language comprehension (Ohnishi et al., 2001) and with perception of music. Verbal memory processes, such as subvocal rehearsal, also take place in the left hemisphere (Baddeley, Gathercole, & Papagno, 1998). Therefore, the greater activations observed in the left PT of musicians may indicate greater performance in verbal memory tasks compared to non-musicians.

Overall, researchers have investigated and found supporting evidence regarding the effect of musical training, or musicianship, on verbal recall in typical children and adult populations. Other researchers have also examined the effect of music as a mnemonic device on verbal memory in typical and clinical populations. Although researchers have accounted for musicianship in studies pertaining to the effect of musical mnemonics on verbal memory, the interaction effect of both musicianship and musical mnemonics has been consistently overlooked. In summation, little research exists regarding the combined effect of musical mnemonics and musical training on verbal memory. This study will provide findings that may support the combined effect of musical mnemonics and musical training on verbal memory, or word recall, in typical populations, and may elicit future research and development of musical experiences for clinical populations.

**Definition of Terms**

**Verbal short-term memory.** Verbal short-term memory (VSTM) is the temporary store of phonological information in which material is encoded and processed...
through a verbal working memory component known as the phonological loop. The phonological loop is specialized for retention of verbal information over a short period of time (Baddeley et al., 1998). The phonological loop consists of two subsystems responsible for the retention of verbal information, which includes the phonological store and articulatory subvocal rehearsal. The phonological store can hold verbal information for approximately one to two seconds (Baddeley, 1992). However, the information can be sustained for a longer period of time through repetition via subvocal articulatory rehearsal. Newly-learned words are maintained in VSTM through rehearsal and repetition (Baddeley et al. 1998). In this study, the term word recall is used to reflect VSTM.

Musical mnemonic. A musical mnemonic is a rehearsal tool that utilizes musical elements, such as rhythm and melody, to enhance the learning of non-musical material.

Musicians. For the purpose of this study, individuals will be considered musicians if they:

a) began learning an instrument before the age of 10 (Jakobson et al., 2008)
b) currently take formal instrumental or vocal lessons
c) practice or play their instrument at least 10 hours a week
d) are majoring in music at the college level (Franklin et al., 2008)

All musicians will also be enrolled in at least nine credits of music classes.

Non-musicians. A musician cannot be defined by any certain characteristic(s) because it is believed that all individuals possess some level of musical skill (Hodges,
1996). However, for the purpose of this study, individuals will be considered non-musicians if they have little to no musical experience or training. Non-musicians will have:

a) received less than one year of formal music lessons, or

b) been engaged in less than two years of self-taught instruction (Jakobson et al., 2008).

**Need for the Study**

Music is an effective tool that can be utilized to improve verbal memory in children and adults in clinical and typical settings. This study will investigate the combined effect of musical training and musical mnemonics on verbal memory in healthy young adults. The findings offer both theoretical and practical relevance.

**Theoretical relevance.** First, the present study provides additional evidence regarding the effect of musical mnemonics on verbal memory in healthy young adults. Second, this study requires recall of unconnected text. Few investigations have utilized this type of recall information (Chazin & Neuschatz, 1990; Rainey & Larson, 2002). Unconnected text is a list of words that have no relation to one another, and do not create a comprehensive sentence or lyrical structure. The use of 14 random Scholastic Assessment Test, or SAT (The College Board, 2012), vocabulary words sung to a familiar melody in this study was used to determine the effect of music on recall of unconnected text. Therefore, this study contributes additional findings to music therapy literature that support the effect of music on short-term recall of unconnected text.

Third, this study provides evidence regarding the effect of musical training on verbal memory in healthy young adults. A growing number of studies investigating the
effect of musical training on verbal memory have shown significantly better verbal recall in musicians than non-musicians. This study contributes to recent literature regarding the effect of musical training on cognitive skills, such as short-term verbal memory and retention.

Finally, the primary aim of this study is to investigate the combined effect of musical mnemonics and musical training on verbal recall in healthy young adults. Because most studies have emphasized the effect of musical training or the effect of musical mnemonics on verbal recall, the combined effect of musical training and musical mnemonics has been overlooked. Therefore, this study reveals the advantages of music as a mnemonic device, in addition to the benefits of music education and training, on verbal memory. This study contributes findings of individual differences between musicians and non-musicians, as well as the effectiveness of musical rehearsal compared to spoken rehearsal. Additionally, this study provides a new area of research, in which the combined effect of musical mnemonics and musical training on verbal memory is examined.

**Practical relevance.** This study provides practical relevance in several ways. First, this study examined the effect of musical mnemonics on verbal recall in typical young adults. If recall is greater following a musical rehearsal, then this study will show that music can be an effective learning device for young adults, and that a musical mnemonic might be a beneficial tool used to study academic material such as word lists, vocabulary, and subject-based content (e.g., math equations, chemistry terms, etc.) at a
college level. This study is also relevant to professionals, such as teachers and music therapists, who may develop musical mnemonic interventions to teach or facilitate learning.

Second, the results of this study may encourage researchers and therapists to use musical mnemonic devices in young adult populations who experience memory deficits, including intellectual disabilities, learning disabilities, multiple sclerosis, traumatic brain injury (TBI), and attention deficit-hyperactivity disorder (ADHD). This study might elicit future clinical research on the effect of musical mnemonics in young adults, especially in TBI populations. The highest incidence rates of TBI are between 15 and 20 years of age (McKinlay, Grace, Horwood, Fergusson, Ridder, & MacFarlane, 2008). Therefore, a musical mnemonic may be an effective tool used to help individuals with TBI to learn or relearn information.

Third, if the outcome of this study shows that musicians achieve greater verbal recall scores than non-musicians, then the effect of musical training on verbal memory will be supported, and consistent with current literature. The findings in this study may also provide evidence to support the importance of music education. Children who experience musical training at primary and secondary education levels (i.e., school band, choir, private lessons) might gain superior verbal memory abilities in comparison with who do not receive musical training. Musical training can facilitate the development of rehearsal strategies that may be used during verbal rehearsal and learning. Therefore, this study may provide evidence that supports the need for music in educational settings.

Furthermore, this study may stimulate interest in the effect of musical training on memory recall with clinical populations with memory deficits. If healthy musicians recall
more verbal information than healthy non-musicians, then the effect of musical training might also enhance verbal memory in clinical populations. Musical training might enhance cognitive development in individuals with memory deficits, as well as enhance rehearsal strategies that may be used during music and verbal learning. Therefore, this study might encourage the inclusion of children with disabilities in the music classroom as evidenced by the therapeutic benefits of music. Moreover, if the findings show a positive relationship between musical training and musical mnemonics on cognitive abilities, then music therapists and music educators might begin to collaborate and develop effective interventions that can be used in educational and therapeutic settings.

Last, this study introduces an area of interest that has yet to be addressed in music-related literature, which is the combined effect of musical training and musical mnemonics on verbal memory. If the outcome of this study shows that musicians produce optimal results following a musical rehearsal of verbal information, then future research should be conducted to further support the combined effect of musical training and musical mnemonics on verbal memory in typical and clinical populations.

**Purpose of the Study**

The purpose of this study was to determine the effect of musical mnemonics on verbal memory, word recall, in musicians and non-musicians. This study investigated the effect of musicianship on word recall in young adults. This study also investigated the effect of mnemonic modality (e.g., sung versus spoken rehearsal) on word recall in young adults. Last, this study examined the combined effect of musicianship and musical mnemonics on word recall in young adults.
Null hypotheses. The following null hypotheses were addressed in this study:

1. There is no main effect of musicianship on word recall in young adults.
2. There is no main effect of mnemonic modality (music or spoken) on word recall in young adults.
3. There is no interaction effect of musicianship and musical mnemonics on word recall in young adults.
Chapter 2

Review of Related Literature

The first section of this chapter will review basic memory and verbal memory processes, and will examine the associated neuroanatomical structures. The second section will present the memory processes involved during music perception and learning. The second section will also review the elements of music that influence memory, as well as the overlapping neuroanatomical structures involved during music and verbal memory processes. The third section of this chapter will summarize previous research that investigated the use of music stimuli as a mnemonic device in verbal memory in typical and clinical populations. The third section will also review literature that shows a positive relationship between musical training and verbal memory. This literature review will provide a rationale for the combined use of musical mnemonics and musical training on verbal memory in young adults.

Memory

This section will first discuss three processes in which learning and memory take place, which includes encoding, storage, and retrieval of information. Next, there is a discussion of three basic memory components of a well-known and highly referenced memory model, which is comprised of sensory, short-term, and long-term memory (Atkinson & Shiffrin, 1968). A primary component of short-term memory, known as working memory will also be discussed, in which four subsystems will be identified. These four subsystems of working memory include the central executive, phonological loop, visuospatial sketchpad, and episodic buffer (Baddeley 2000, 2012; Baddeley &
Hitch, 1974). Last, the processes involved during verbal learning and memory will be discussed, followed by the identification of the associated neuroanatomical structures.

**Basic memory processes.** Memory is comprised of three distinct stages, which include encoding, storage, and retrieval (Gazzaniga et al., 2009). Encoding is a two-stage process in which incoming information is processed to be stored in memory. The two stages include acquisition and consolidation. Acquisition is the process of registering incoming sensory stimuli for analysis, and consolidation occurs when the information is transferred into long-term storage. Storage is the permanent holding of information, and retrieval is the extraction of information from memory.

Atkinson and Shiffrin (1968) first introduced an empirical memory model based on three memory processes, including sensory, short-term, and long-term memory. Since then, researchers have referenced the Atkinson and Shiffrin (1968) memory model in published research and textbooks (Baddeley, 1992; Cowan, 2008; Gazzaniga et al., 2009). Other researchers have also expanded beyond the original memory model and added new components, such as working memory, and theories of interaction between sensory, short-term, and long-term memory processes (Baddeley, 1986, 1992, 2000, 2012; Baddeley & Hitch, 1974; Cowan, 2008).

Sensory memory is a subconscious phenomenon that occurs when an individual actively or passively attends to stimuli, in which large amounts of incoming sensory information are held for a very brief period of time. Information can be held for up to 10 seconds (Sams, Hari, Rif, & Kuutila, 1993) and can decay in as quickly as 500 milliseconds (Gazzaniga et al., 2009). Sensory information consists of auditory, visual, and somatosensory stimuli, such as olfaction and taste. Visual sensory memory is also
known as iconic memory, and auditory sensory memory is referred to as echoic memory (Gazzaniga et al., 2009). Selected information becomes encoded and transferred from sensory memory into a storage network greater in retention time, known as short-term memory.

Short-term memory (STM) is the temporary storage of information over several seconds to minutes. STM is longer lasting than sensory memory, but more limited in storage capacity. According to an empirical study, which many researchers continue to reference, Miller (1956) stated that STM holds up to seven items of information, plus or minus two items. However, the capacity can be increased using a technique known as chunking, or the grouping of large amounts of information into smaller and meaningful units. For example, chunking a group of ten items such as 5670982351 into three smaller units, 567-098-2351, is a more effective approach to encoding information.

Through encoding and rehearsal processes that take place in STM, the information eventually transfers to long-term memory (LTM), which is the permanent storage of memories and information that can last up to a lifetime (Gazzaniga et al., 2009). A critical component of STM that is responsible for the rehearsal and transfer of information to LTM is working memory (Baddeley, 1986, 1992, 2000). STM and working memory are associated with activations in the prefrontal cortex and areas of the medial temporal lobe (Milner, 1998).

Working memory is the maintenance and manipulation of information, and is comprised of three subsystems, including the visuospatial sketchpad, phonological loop, and central executive (Baddeley, 1986, 1992; Baddeley & Hitch, 1974). In 2000, Baddeley proposed a revised working memory model, called the multicomponent model,
which included a fourth component known as the episodic buffer. Baddeley (2000) described the episodic buffer as a temporary store of integrated sensory information. The episodic buffer is distinguished by interactions between sensory stimuli and perception, in which a limited amount of integrated chunks of information become stored as multidimensional representations in LTM (Baddeley, 2000, 2003, 2012). Therefore, the concept of the episodic buffer enables researchers to understand the interaction between STM, perception, and LTM when processing new sensory information.

The primary role of the central executive is attentional control of action, in which focus, storage, and decision-making take place (Baddeley, 2012). The central executive controls the working memory subsystems which include the episodic buffer, phonological loop, and visuospatial sketchpad (Baddeley, 1992, 2000, 2012; Baddeley & Hitch, 1974). The central executive also serves as an interface between the phonological loop, visuospatial sketchpad, and LTM (Baddeley, 1996, 2012). The visuospatial sketchpad stores visual and spatial information, and the phonological loop stores acoustic and verbal information by utilizing a temporary store and an articulatory subvocal rehearsal system. The phonological loop also plays a critical role in the acquisition of new words (Baddeley et al., 1998).

The transfer of verbal information from short-term to long-term memory occurs within the phonological loop through subvocal articulatory rehearsal, which is the overt and covert rehearsal of verbal material (Baddeley, 1986, 2000, 2012; Baddeley & Hitch, 1974; Baddeley et al., 1998; Cowan, 2008). Overt rehearsal occurs when an individual imagines a piece of verbal information and recites the words out loud (Cowan, 2008). Covert rehearsal occurs when an individual recites the words internally, also referred to as
as inner speech (Baddeley, 1992). Speech-based and acoustic information can last up to two seconds in the phonological loop if coupled with subvocal rehearsal (Baddeley, 1992). Rehearsal of verbal information takes place in the dorsal and posterior areas of the prefrontal cortex (Robertson, 2002).

Verbal information transfers to LTM when it is rehearsed over time. LTM consists of two types of memory, including declarative and nondeclarative memory (Gazzaniga, et al., 2009). Declarative memory consists of episodic memory; the recollection of past life events or episodes, and semantic memory; the recollection of general facts and knowledge. Declarative memories are associated with activations in the medial temporal lobe (Milner, 1998). This study will address the recall of semantic verbal information.

Nondeclarative memory consists of four types, including procedural memory, perceptual representation system (PRS), classical conditioning, and nonassociative learning. Procedural memory consists of learned cognitive and motor skills, such as riding a bicycle or using a toothbrush. PRS, also known as perceptual priming, is the identification of a stimulus that has been previously experienced. Classical conditioning is a learned response when a specific stimulus is presented repetitively. Nonassociative learning is the decrease or increase in response when a stimulus is presented repetitively, which is also known as habituation.

Additionally, LTM plays a critical role during STM neuroanatomical and perceptual processes. Several brain areas that are associated with LTM are also active during STM processes including working memory and language processing (Baddeley, 2012). The consolidation of information from STM to LTM takes place in the
hippocampal formation and areas adjacent to the temporal lobe (Robertson, 2002). This shared network of activations between STM and LTM processes means that both memory storage units work together. Most importantly, the memories stored in LTM influence the perception and selection processes that take place in sensory memory and STM. In other words, attention to new stimuli for further encoding into memory is influenced by familiarity, which is linked to already-learned information that is stored in LTM. The interaction between STM and LTM also exists in processes involved in verbal short-term memory.

**Verbal short-term memory.** Verbal information becomes stored in memory through processes within the phonological loop, which is a component of the working memory system. The central role of the phonological loop is to store novel speech patterns, thus producing and transferring newly-learned words into LTM (Baddeley et al., 1998).

The phonological loop consists of two subsystems including a phonological store and subvocal articulatory rehearsal (Baddeley, 1986; Baddeley & Hitch, 1974; Baddeley et al., 1998). The phonological store is responsible for the short-term retention of verbal information, which can last up to two seconds (Baddeley, 1996). The verbal information can be maintained for a longer period of time via subvocal articulatory rehearsal (Baddeley, 1996; Burgess & Hitch, 1992). Therefore, the role of subvocal articulatory rehearsal is to preserve and prevent phonological representations from fading in the phonological store (Baddeley, 1986). Subvocal rehearsal is the process of overt or covert practice and repetition of verbal information.
Vallar (2006) proposed a model that clearly illustrates the functions and processes involved in the phonological loop. First, incoming auditory information is analyzed and transferred into the phonological short-term store (STS), or phonological store. The information then enters the phonological output buffer where subvocal articulatory rehearsal takes place. Verbal information that is covertly (e.g., inner speech) rehearsed or repeated re-enters the phonological STS. Verbal information that is overtly rehearsed (e.g., spoken out loud) re-enters through the ears to the phonological STS by way of verbal auditory feedback. The re-entering of information to the phonological STS is repeated through each rehearsal. The information becomes transferred into LTM if given ample rehearsal. Vallar’s model also accounts for visual encoding, where visually presented verbal material enters the phonological STS and is processed in terms of phonological code (Baddeley, 2003). Visual encoding is relevant for individuals who may learn auditory verbal information along with a visual aide.

A unique contribution of Vallar’s (2006) model is the relationship and interaction between the phonological store and subvocal articulatory rehearsal mechanism. The model also emphasizes the importance of subvocal rehearsal in terms of the acquisition and consolidation of verbal information.

The systems of the phonological loop are operated by different neural structures primarily located in the left hemisphere (Baddeley, 2003; Vallar, 2006). The phonological loop connects posterior temporal areas with the inferior parietal lobe and ventrolateral prefrontal cortex (Aboitz, Aboitz, & García, 2010). The inferior parietal lobe is associated with Brodmann Areas (BA) 39 and 40, which are active during
processes within the phonological store (Paulesu, Frith, & Frackowiak, 1993; Vallar, 2006). The phonological store is also associated with activations in the ventrolateral premotor cortex (Koelsch et al., 2009).

The ventrolateral prefrontal cortex is associated with Broca’s area, including BA 44 and 45, which are active during articulatory subvocal rehearsal (Paulesu et al., 1993). Broca’s Area is also associated with speech production (Gazzaniga et al., 2009). Additionally, activations in the premotor cortex, including BA 6 and the supplementary motor area (SMA) are associated with articulatory subvocal rehearsal (Koelsch et al., 2009; Vallar, 2006). Therefore, areas located within the inferior parietal lobe are associated with storage of verbal information, and areas within the ventrolateral prefrontal cortex and premotor cortex are associated with subvocal rehearsal of verbal information.

Tasks that require verbal STM also demand increased attentional processes as evidenced by large activations in the anterior cingulate, which regulates attention, and BA 10, which is associated with encoding in the left frontal lobe (Andreason et al., 1995). These activations in the anterior cingulate and BA 10 show the significant role of attention and encoding when learning new verbal information.

**Summary.** Information is processed in three stages of memory, including sensory memory, STM, and LTM. Sensory information is first encoded into STM, in which selected information is maintained and rehearsed via working memory processes. Larger amounts of information are more easily learned through chunking, or the grouping of information into smaller units. Through repeated rehearsal, the information transfers from
short-term to long-term memory. Information is more likely to be transferred to LTM if rehearsed a sufficient amount of time (Baddeley, et al., 1998). Information can last up to a lifetime in LTM.

Verbal STM incorporates two components of the phonological loop, including the phonological store and subvocal articulatory rehearsal. The phonological store is limited in capacity and duration of retention of verbal information. However, the processes involved during articulatory subvocal rehearsal help maintain verbal information for a longer period of time in the phonological store until it is transferred into LTM. Therefore, verbal information is transferred to LTM through repetition and rehearsal. The information will fade over time if it is not sufficiently rehearsed.

Neuroanatomical activations in the ventrolateral prefrontal cortex, inferior parietal lobe, and motor areas take place during verbal STM processes. The phonological store is associated with neural regions that are responsible for storage of information, such as the inferior parietal lobe, including BA 40. The articulatory subvocal rehearsal is associated with neural regions responsible for motor and attentional processes, such as the premotor cortex, ventrolateral prefrontal cortex including Broca’s Area (BA 44 and 45), and the anterior cingulate (BA 10).

Finally, information that is selected and attended to during sensory and STM processes are influenced by past memories stored in LTM. Information that is transferred to long-term storage is selected based on familiarity, patterns, and predictability. Therefore, the interaction between STM and LTM plays a critical role during encoding processes and learning new information. The relationship between STM and LTM is important because memory for music is also processed in a similar fashion.
Music and Memory

This section will discuss the influence of Gestalt laws of perception and schemata on memory for music. Next, this section will examine the elements in music that influence musical perception and memory, followed by identification of the associated brain structures. This section will also identify shared and distinct neural structures involved during verbal and musical memory in musicians and non-musicians.

Music Schemata and Gestalt Laws of Perception

Auditory information is received and processed in three steps, including sensation, perception, and cognition. Sensation is the interaction between an organism and the environment (Lipscomb, 1996). Perception is the filtering of select information for further processing, and cognition is the acquisition, storage, and retrieval of information (Lipscomb, 1996). Two factors that play a significant role in sensation, perception, and cognition of music are the Gestalt laws of perception and schemata.

Gestalt laws of perception. Large amounts of information are more easily learned when grouped into smaller units. The process of grouping information is also known as chunking, in which information is combined into more meaningful units (Cowan, 2008). According to the law of Pragnanz introduced by Koffka (1935), humans innately perceive organization by grouping, or chunking, units of information together. Musical information is comprised of structural elements, such as melody and rhythm, that provide organization and patterns suitable for chunking. For example, melodic phrases can provide predictable and repetitive patterns, and rhythmic groupings can provide temporal cues. Grouping musical information into units of structured patterns is a bottom-up process, known as primitive grouping (Bregman, 1990). The Gestalt laws of
perception are the underlying mechanisms that enable the primitive grouping of musical information based on the structure of musical elements and patterns (Bregman, 1990; Tan, Pfordresher, & Harré, 2010).

Some of the Gestalt laws of perception that are evident in music include proximity, similarity, common fate, and good continuation (Lipscomb, 1996). Proximity pertains to the distance between elements of a stimulus. In music, two pitches that are close in distance create an interval that tends to be grouped together and perceived as one unit (Deutsch, 1999; Tenney & Polansky, 1980). When notes are further away from each other, it is less likely the notes will be grouped together. For example, a stepwise ascending melodic phrase can be more easily perceived as a single unit because it follows a predictable upward pattern. Proximity in pitch is one of the most important factors in terms of grouping auditory information (Deutsch, 1999; Tan et al., 2010).

Similarity in music occurs when sound structures share common features. Musical elements that can be grouped together based on similarity include timbre, tonality, melody, rhythm, pitch, and volume. Similarity is also evident during the repetition of musical phrases, motives, and themes. Musical repetition provides redundancy, organization, and a frame of reference for listeners, through which learning can take place.

Common fate occurs when musical cues at the end of a melody, such as cadences or melodic sequences, indicate resolution to the tonic note (Snyder, 2000). The cue creates an expectancy effect, in which a listener anticipates closure of a melody based on
the auditory cues. Upon hearing an unresolved melody, Tan et al., (2010) describe common fate as the tendency to perceive music as a whole by automatically closing the gap. Common fate is most associated with melodic and harmonic resolution.

Good continuation means objects or notes follow the same direction or pattern. Elements that follow each other in a given direction are perceptually grouped together (Deutsch, 1999). Units of information are grouped together when musical elements follow similar patterns, such as descending or ascending scales.

The Gestalt laws of perception play a critical role in the grouping of musical information based on the natural ability to detect patterns (Snyder, 2000). Through musical elements, such as melody and rhythm, an individual can more easily perceive and group patterns of information. Additionally, musical information can be grouped into meaningful units based on interconnections shared between new stimuli and stored memories. In other words, like basic non-musical memory processes, memories stored in LTM play a significant role in the perception and learning of new musical information. LTM influences the perception, selection, and encoding of musical information within the sensory memory and STM domains. This interaction between STM and LTM is also known as schemata.

**Schemata.** Musical information can be grouped based on a top-down process, in which incoming information is interpreted based on previously learned knowledge, or schemata (Tan et al., 2010). Auditory information must first be selected and attended to in order to enter sensory memory. Information is selected according to characteristics that are associated with previously learned and stored information. Auditory stimuli that are attended to become extracted from other incoming noise and bound together into units of
information that share similar sound characteristics relative to tone, pitch, melody, and timbre. Snyder (2000) defines the extraction of musical information as feature extraction.

Perceptual binding is the process of combining the selected musical features into a single meaningful unit of auditory information. The units of information then become linked to and grouped with long-term memories that share similar auditory characteristics. This ability to link and group new information with stored memories that contain similar features is a top-down process influenced by schemata, also known as schema-driven grouping (Bregman, 1990).

Individuals perceive and learn music based on schemata, which consist of rhythmic-melodic configurations that occur frequently within a cultural context, and that are stored in long-term memory (Lipscomb, 1996). Schemata effects how and to what musical features a listener attends. The listener’s long-term schematic knowledge of his or her own musical culture shapes the perception of music (Curtis & Bharucha, 2009). Schemata also effects familiarity with musical elements, which can shape the expectations of a listener (Tan et al., 2010). Schema facilitates attention to specific musical characteristics because it generates a certain level of expectation in music by guiding listeners to predict what will happen, what to attend to, and what is retained in memory (Lipscomb, 1996).

Schema plays an essential role in the perception of music, which encompasses elements such as scales, tonality, rhythm, timbre, and melody. Scales are perceived differently between cultures, but also share several similarities. For example, musical scales share several rules across cultures. Scales should contain: 1) pitches that are
distinguishable, 2) octaves that are equivalent in pitch class, 3) a moderate number of pitches, and 4) a uniform modular pitch unit from which intervals are built, such as a semitone (Dowling & Harwood, 1986; Lipscomb, 1996).

In Western music, tonality provides a basis for pitch memory because the melodic structure is centered on the tonic note. Pitches that are relative to the tonic note create familiar intervals that are more prone to recognition and memory. Pitches that are not relative to the tonic may be more difficult to learn and perceive because of unfamiliarity. For example, individuals of different cultures develop certain musical expectations and tastes. Infants in the Western part of the world are typically exposed to major and minor tonalities through song, such as lullabies and play songs. Infants can learn to associate musical tonality with mood and social cues (i.e., an upbeat song in a major key indicates a playful mood). The early exposure to Western musical characteristics, in addition to the constant exposure throughout development, influences how new musical information is perceived. Therefore, individuals of the Western culture can perceive a melody that is written in a major or minor key more easily than a melody based on the tonality of another culture, such as an Indian raga. Although the melody of an Indian raga might be enjoyable to a person of the Western culture, the ability to learn the musical information would be challenging because the musical characteristics are not associated with memories already stored in schemata. Therefore, schemata can influence the perception and interpretation of a melody through familiar and predictable musical characteristics such as patterns, scales, pitch, and tonal resolution (Curtis & Bharucha, 2009).

Rhythm provides metrical organization in which musical structures are grouped into patterns. Metered groupings of rhythmic patterns produce expectation, predictability,
and familiarity to the listener. Perception of rhythm is influenced by experience and memories that make up one’s schemata (Lipscomb, 1996). Rhythmic-melodic configurations that occur frequently within a cultural context are stored in long-term memory (Lipscomb, 1996). Therefore, schemata influence the perception of rhythm, in which stored memories facilitate the selection of familiar and predictable patterns that are heard in new music.

This schema-driven grouping of musical information shares similar processes associated with basic STM and LTM processes; that is, the ability to learn and perceive new information is influenced by memories stored in LTM, or schemata. Therefore, the ability to learn new musical and nonmusical information can be influenced by schemata. In other words, the concept of schemata in terms of acquisition and consolidation of information is a process shared in music and nonmusical perceptual and memory processes.

**Summary of gestalt laws of perception and schemata.** In summary, the Gestalt laws of perception and schemata help to explain how new musical information can be learned. The Gestalt laws of perception represent a bottom-up process, in which musical information is chunked, or grouped, based on the perception of structural elements, including patterns and organization. Schemata is described as a top-down process, in which schema-driven grouping of musical information is based on associative memories stored in LTM. Information is attended to and processed for further encoding based on characteristics that are familiar and predictable.

Acoustic elements such as tonality, pitch, rhythm, melody, and timbre play an important role in the grouping of information because they provide organization, patterns,
predictability, and familiarity, which give meaning to musical information. These acoustic characteristics can enhance the ability to encode, transfer, and retain musical information in long-term storage.

Music and language also share similar perceptual processes, in which the attention and selection of incoming stimuli is influenced by patterns, structure, and familiarity. Music and verbal information are encoded and processed based on schemata, in which past memories influence the selection and extraction of new information based on familiar acoustic characteristics. For example, an English speaker can learn English vocabulary more easily than German vocabulary because English, the native language, is more familiar and shares similar vernacular characteristics that are permanently lodged in LTM. Additionally, new musical information is also more easily learned if similar acoustic features are stored in LTM, such as major and minor tonalities.

Other similarities shared between verbal and musical memory processes have also been observed in neuroimaging studies. Several researchers examined the structures involved during verbal and musical memory processes.

**Neuroanatomy of Music and Verbal Memory**

This section will identify several structures associated with music and memory, in addition to the overlapping structures during verbal memory processes. In one study examining the structures involved during verbal and tonal rehearsal tasks, Koelsch et al. (2009) found overlapping activations in the premotor cortex, planum temporale (PT) within Wernicke’s Area, intraparietal sulcus (IPS), anterior insula, prefrontal areas, basal ganglia, and cerebellum primarily in the left hemisphere. Another study showed
activations in the anterior insula, as well as the left posterior Sylvian cortex (Spt), Broca’s area, and left premotor regions during music and verbal rehearsal (Hickock, Buchsbaum, Humphries, & Muftuler, 2003). Researchers have also found activations in the left temporal and prefrontal cortices during semantic musical and verbal memory tasks (Groussard et al., 2009).

These findings indicate the significant role of motor areas, such as the premotor cortex and cerebellum, during verbal and tonal working memory processes in which rehearsal takes place. The posterior Sylvian cortex (Spt), which is between the parietal and temporal lobes, also plays an important role during the internal rehearsal of verbal and tonal information. Other areas, such as the PT within the temporal lobe and anterior insula of the frontal lobe, are involved in the maintenance and processing of music and language. The parietal lobe (including BA 40) is responsible for the integration and storage of auditory information, and the temporal lobe plays an active role in recognition of familiar melodies (Satoh, Takeda, Shimosegawa, & Kuzuhara, 2006).

Furthermore, other studies have investigated the effect of musical training on verbal memory, in which researchers found interactions between musical training and cognitive development in musicians and non-musicians. Researchers found greater left hemispheric activation in the posterior superior temporal lobe, which includes the PT, and the auditory cortex in musicians (Ohnishi et al., 2001; Schlaug et al., 1995). The researchers explain that the posterior superior temporal region is associated with music perception, and that musical training can influence greater left hemispheric activation.
These findings are important because language is also processed in the left hemisphere. Therefore, musical training might produce greater activation in the left hemisphere, thus enhancing verbal memory abilities in musicians.

Other researchers also provide evidence that supports the effect of musical training on enhanced activation in both hemispheres of musicians. Schulze, Zysset, Mueller, Friederici, and Koelsch (2011) examined the neural structures involved during verbal and tonal working memory (WM) tasks in musicians and non-musicians. The results showed that tonal and verbal WM processes recruited distinct and overlapping neural structures in both musicians and non-musicians.

First, the results showed activations in the right insular cortex during verbal WM tasks, and the globus pallidus, right caudate nucleus, and left cerebellum during tonal WM tasks. Second, the researchers found that the structures involved during the verbal WM tasks in the non-musicians were active during both verbal and tonal WM tasks in the musicians. Some areas included the left premotor cortex, left parietal lobe, supplementary motor area (SMA), left insula, Broca’s area, and right cerebellum. However, the right premotor cortex, left putamen, and right cerebellum showed greater activations during the tonal WM tasks. The left premotor cortex, left insula, and Broca’s area showed greater activations during the verbal WM tasks. The left insula is associated with verbal production and processing, as well as tonal rehearsal in musicians (Schulze et al., 2011).

The findings in this study indicate that verbal and tonal WM processes embody distinct and shared neural activations in musicians and non-musicians. Additionally, the findings showed that some structures associated with verbal WM tasks were also active during the tonal WM tasks in musicians only. Therefore, this study shows the effect of
musical training on WM, in which bi-hemispheric activation during both verbal and tonal WM is evident in musicians. The results of these studies provide foundational and scientific evidence that supports the effect of musical training on verbal memory.

Summary. In summary, these studies have identified several neural structures that are active during both verbal and musical memory processes, including the rehearsal and storage of information. Furthermore, these studies examined the similarity and differences in neurological activations during working memory tasks between musicians and non-musicians.

Music perception and verbal memory processes utilize distinct and shared neural networks, including the prefrontal cortices, premotor areas, left parietal and temporal lobes, anterior insula, and cerebellum. The neurological overlap shows that musical and verbal information are processed in a similar fashion.

Furthermore, researchers found greater activations in the left posterior superior temporal lobe, including the PT, of musicians during music listening tasks. These areas are associated with music perception as well as language processing (Ohnishi et al., 2001). Because verbal information is predominantly processed in the left hemisphere, the greater activations observed in the left hemisphere of the musicians during the music listening tasks shows the overlapping areas associated with music and language. Therefore, this left hemispheric advantage might indicate better verbal memory skills in musicians than non-musicians.

Researchers also found that neural structures that were involved during verbal WM tasks in musicians and non-musicians were also active during tonal WM memory
tasks in the musicians only. This finding indicates a bi-hemispheric activation in
musicians during verbal and tonal WM, in which structures involved during verbal WM
were also active during tonal WM tasks in musicians only. Therefore, musical training
may enhance verbal memory skills as evidenced by bi-hemispheric activations in
structures that are associated with verbal WM and tonal WM tasks.

These studies provide reason to investigate the effect of musical training on verbal
memory. In addition to neurological research, the theory of bottom-up and top-down
processing of musical information also supports the effect of music on verbal memory in
individuals, specifically through elements such as rhythm and melody. Therefore,
researchers have investigated the effect of music as a mnemonic aide on verbal memory
in healthy individuals, as well as clinical populations, in addition to the effect of musical
training on verbal recall.

**Mediating Effects of Music on Verbal Memory**

Individuals tend to learn new information more effectively when it is grouped into
organized patterns of information. Music can enhance learning because it provides
structural elements that help group information into organized units. Thaut (2010)
suggests that the highly developed temporal functions in music serve as a metrical
template that helps to organize and chunk information into more manageable units.
Therefore, a musical mnemonic can be an effective rehearsal tool used for learning,
storing, and recalling verbal material.

This section will review literature that supports the mediating effect of music on
verbal memory in a variety of populations. First, the effect of music as a mnemonic
device on verbal memory in healthy populations will be discussed. Next, this section will
examine the effect of music as a mnemonic device on verbal recall in clinical populations, including learning disabilities, multiple sclerosis, and Alzheimer’s disease. Last, this section will review literature that examined the relationship between musical training and verbal memory.

**Music as a mnemonic aide.** A musical mnemonic can be a useful learning tool for the memorization of verbal information, including lyrics, facts, number combinations, names, and more. Musical elements, such as rhythm and melody, provide structure and organization that may enhance verbal memory and recall (Wallace, 1994; Thaut, Mertel, & Leins, 2008). Another aspect of music that may facilitate verbal recall is familiarity. Chazin and Neuschatz (1990) investigated the effect of familiar music on verbal recall in young children and young adults, who were randomly assigned to a song or lecture group.

The researchers created a spoken and sung recording about several minerals, including the name, color, and one random fact. The lyrics about the minerals were sung to the melody of “Mary Had a Little Lamb” in the song group. The participants in the song group first listened to the recording one time. Then they were given the printed lyrics and were instructed to sing along with the recording two more times. Following the third presentation, the participants were given an immediate recall test, in which they recalled and wrote down as many words or phrases from the song as possible. One week later, a delayed-recall test was administered, in which the participants were asked to recall and write down as many words from the song as possible.

The participants in the lecture groups followed the same procedure as the song group, except that the same information was presented in a spoken format without a
musical accompaniment. Rather than singing along, the participants were encouraged to speak along with the audio recording. The same immediate and delayed-recall tests were administered.

The researchers accounted for familiarity of the verbal material when data were analyzed, in which the participants reported whether the information about the minerals was known or unknown. The results showed that both children and young adults in the song group, who were unfamiliar with the minerals, recalled significantly more information than the participants in the lecture group in the immediate recall task. Significant results were not observed in the delayed-recall of unfamiliar information. Additionally, the results showed no significant results in the immediate- and delayed-recall tasks in participants who were already familiar with the information. Therefore, this finding indicates that musical mnemonics do not aide in the immediate or delayed-recall of familiar material, but do facilitate the immediate recall of newly-learned information.

The researchers explain that the significant results in the immediate recall task were due to familiarity with the music because the cognitive load was not overburdened. The participants were required to learn only the lyrics, and not the melody or rhythm of the song. The familiar melody enhanced verbal memory because it grouped the new material into associative links (Chazin & Neuschatz, 1990). However, the long-term effect of the musical mnemonic was not evident because the information was not maintained through rehearsal. The participants heard the recording three times, which may have been an insufficient amount of rehearsal. Therefore, the number of repetitions should be considered when the long-term effect of verbal recall is examined.
The researchers recommend the use of more simple material for younger participants in order to increase the understanding and spelling of the words. The researchers chose minerals that were difficult to spell and sound out for the younger participants, such as Sylvanite, Limonite, and Apatite. The use of simpler words may have been less taxing for the younger groups. This suggestion indicates the importance of using age-appropriate material to avoid a ceiling or floor effect.

Familiar music plays a significant role in learning new verbal information, as well as other aspects of music, such as melody and rhythm. Wallace (1994) conducted four experiments to investigate the effect of music on verbal recall, and to identify and explain why specific musical elements, such as rhythm and melody, may help enhance verbal memory. The first experiment showed the effect of music on text recall in young adults. Participants were randomly assigned to listen to a three-verse ballad that was presented in a sung or spoken format throughout five trials. The participants were asked to recall the lyrics in writing after the first, second, and fifth trial. A distraction task was then implemented that followed the same procedure, in which a different ballad was presented throughout five trials, and with several recall tasks. As part of a delayed-recall task, the participants were then asked to recall the lyrics from the first ballad after the distraction task was completed.

The results showed that text recall significantly improved over the first three trials, and slightly decreased in the delayed-recall trial in both conditions, indicating a significant effect of repetition (sung or spoken) on verbal recall. The results also showed that the participants in the sung condition recalled the text significantly more accurately than the spoken condition in all recall trials. This finding indicates that music can
enhance verbal recall. Wallace (1994) suggests the participants were more aware of the temporal structure of the rhythm, which enabled the ability to chunk the words and sentences into more meaningful units.

In the second experiment, Wallace (1994) identified musical elements, other than rhythm, that play a significant role in verbal recall. The participants heard recordings of the same three-verse ballads from the first experiment in a sung or rhythmically spoken format, which was presented by emphasizing the rhythmic stress of each syllable (Wallace, 1994). The protocol was identical to the first experiment, which included five trials, a distraction task, and a delayed-recall task. The results showed that the participants in the sung condition recalled the text significantly more accurately than the participants in the rhythmically spoken condition in all recall trials. Therefore, the results of Experiment 2 indicate that melody, along with rhythm, also plays a significant role in verbal learning and text recall.

In the third experiment, Wallace (1994) further investigated the effect of melody on verbal recall. The participants listened to a one-verse ballad that was presented in a sung or spoken format. The procedure was identical to the first and second experiments. The results showed that the participants in the spoken condition recalled the text significantly more accurately than the sung condition in all recall trials, indicating the significant role of melodic familiarity and repetition on verbal recall. In other words, the participants recalled significantly more accurate information in the spoken condition because the melody was not familiar in the sung condition.

In the first experiment, three verses were sung to the same melody, meaning that the participants heard two additional repetitions of the melody in each trial compared to
those in the third experiment, who only heard the melody one time per trial. Therefore, the lack of melodic repetition inhibited the participants from gaining familiarity with the melody, resulting in poor recall performance. The results indicate that a melody that becomes familiar through repetition can facilitate verbal recall more effectively than an unlearned, or unfamiliar, melody.

In the final experiment, Wallace (1994) further examined the effect of musical elements and melodic repetition on verbal recall. A new three-verse ballad was recorded and presented in three different versions; spoken, three verses sung to the same original melody, and three verses sung to three different original melodies. The protocol followed the same format as the first three experiments except for the delayed-recall task, which was excluded. Results showed that the participants who heard the three verses sung to the same melody recalled text significantly more accurately than the other two conditions. The results indicate that melodic repetition and familiarity can facilitate the immediate acquisition and recall of verbal information. Furthermore, the findings indicate that melody and rhythm provide structural components, such as phrasing and temporal cues, that can enhance verbal memory.

Wallace (1994) suggests that an effective musical mnemonic should preserve the authenticity of each word by matching the number of notes to the number of syllables, matching the melodic contour to the appropriate verbal syntax, and utilizing rhythmic and melodic patterns that match the accentual structure of the text. Music provides structure through rhythmic and melodic elements that help organize, cue, and chunk text into meaningful units of information. Additionally, repetition and familiarity may help
improve verbal memory. Other researchers have also investigated the effect of musical familiarity and repetition on verbal memory (Purnell-Webb & Speelman, 2008).

The researchers conducted two experiments to examine the effect of music on verbal recall. The first experiment investigated the role of melodic repetition, the role of rhythm, and the effect of familiar music on verbal recall (Purnell-Webb & Speelman, 2008). Additionally, the researchers examined the effect of melodic phrasing on the ability to chunk information. The participants were randomly assigned to one of five conditions, including familiar melody, unfamiliar melody, unknown rhythm, known rhythm, and spoken.

The study employed the verses from the ballads used in Wallace’s (1994) study. The lyrics were sung to the melody of “Scarborough Fair” in the familiar melody condition, and to an original melody in the unfamiliar melody condition. The verses were spoken in time to a rhythmic accompaniment based on the song, “Scarborough Fair” in the known rhythm condition, and spoken in time to a rhythmic accompaniment based on an original composition in the unknown rhythm condition. Last, the verses were spoken without a rhythmic or melodic accompaniment in the spoken condition.

The participants listened to the first verse, and were asked to recall and write down as many words as possible. The participants were given the same task for verses two, three, and four as well. Then the participants listened to all four verses at one time, and were asked to recall and write down as many words as possible. The participants listened to the presentation three more times, followed by a final recall task. Then the
researchers administered a 15-minute distraction task, in which the participants filled out a questionnaire. Finally, the participants were asked to recall and write down as many words from the text as possible.

Results of the first experiment showed that the participants in the familiar melody condition recalled significantly more words than the unfamiliar melody condition. Although the repetition of the unfamiliar melody may have become more familiar over time, there were no significant differences observed throughout the recall trials. This finding supports the effectiveness of familiar melodies on verbal recall.

Results also showed no significant differences between both rhythm conditions and the familiar melody condition. The participants in the known rhythm, unknown rhythm, and familiar melody conditions recalled significantly more words than the unfamiliar melody and spoken conditions. This finding indicates that familiar or novel rhythms, in addition to familiar melodies can enhance verbal recall. The researchers explain that rhythm may facilitate verbal recall because textual information naturally contains speech patterns and accents that are rhythmic. Therefore, rhythm provides cues that may help chunk the information into meaningful units.

The second experiment was identical to the first, except for the conditions which included familiar rhythm, unfamiliar rhythm, unfamiliar melody, unfamiliar melody with training, and spoken. In the unfamiliar melody with training condition, the participants l
listened to six presentations of an unknown melody before the lyrics were added in order to gain familiarity with the melody. All recall and delayed-recall trials were implemented in the same format as the first experiment.

The results showed that the participants in the familiar rhythm condition performed significantly better than the other conditions in every recall trial. The researchers explain that the familiar rhythm might have facilitated recall for two reasons. First, rhythm provides a framework that groups text into meaningful phrases. Second, rhythm matches the natural rhythm of the text because it follows similar patterns of strong and weak beats, which might function as a retrieval cue for text.

In conclusion, the results of both experiments showed the significant effect of familiar melody and rhythm on verbal recall. Familiar melody and rhythm facilitate verbal recall because the structural framework provides retrieval cues, matches the natural prosody and rhythm of speech within a musical context, and enables a listener to chunk information. Unfamiliar music may also facilitate the ability to chunk information because it still provides retrieval cues and familiar musical structure that influence predictability in patterns. However, the researchers suggest that the unfamiliar melody did not facilitate recall in this study because of cognitive overload, in which the participants were required to learn new text, new melodies, and new rhythmic patterns. Therefore, rhythm and familiar melody can significantly enhance verbal recall through predictable patterns that help chunk information and provide retrieval cues.

The ability to chunk information into more meaningful units is one characteristic of music that helps enhance verbal recall. Other researchers have investigated the relationship between music and chunking. McElhinney and Janet (1996) further
examined the effect of music on the ability to chunk verbal information into meaningful units. The participants were randomly assigned to either a spoken or sung group. The researchers presented a sung recording of Billy Joel’s “You’re My Home” to the participants in the sung group, and a spoken recording of the same lyrics without a musical accompaniment to the spoken group. All the participants were reportedly unfamiliar with the song. The recording was heard three times. After each presentation, the participants were asked to recall and write down as many words as possible.

The researchers recorded the total number of words recalled, regardless of order. The results showed that participants in the spoken and song groups recalled significantly more words between each trial, indicating the significance of rehearsal (musical and spoken) on learning. The results also showed that the participants who heard the sung lyrics recalled significantly more words in Trials 2 and 3 than the participants who heard the spoken lyrics. This finding indicates that music can better facilitate word recall than spoken rehearsal.

In order to examine the effect of music on chunking, the researchers recorded the number of words recalled by each unit, or phrase, of information. The results showed that the participants who heard the sung recording recalled significantly more units of information in all three trials than their counterparts. This finding demonstrates the impact of musical structure on the ability to chunk information into meaningful units, which results in greater word recall. The researchers suggest that the melody and rhythm of the song may have enhanced organization of the information, which resulted in larger
groupings of information and greater recall. Although the song was unfamiliar, the structural components of the music may have been familiar and predictable, thus providing retrieval cues during the recall trials.

Familiar music can also facilitate the ability to learn a new language. Research has shown the significant effect of musical mnemonics on language acquisition in young adult non-native English speakers (Kamahara, 2003). The participants were first given a pre-test, which included a one-word recognition test and a vocabulary word acquisition test, so the researcher could gather baseline data regarding the participant’s initial knowledge of the vocabulary words and their meanings. The participants were randomly assigned to either a verbal or music condition, in which 14 vocabulary words and synonyms were rehearsed. During each rehearsal session, the participants watched and listened to videotape, which included the auditory presentation paired with a visual presentation of the words. The words were spoken in the spoken condition, and sung to the melodies of several Beatle’s songs in the musical mnemonic condition. The presentation of the words was given three times, and the participants were encouraged to speak along, or sing along with the presentation. The rehearsal lasted 20 minutes, and occurred three times in one week. Therefore, the participants rehearsed the vocabulary words on three separate occasions.

The researcher then administered a post-test, which was identical to the pre-test. The results from the post-test were compared with the results in the pre-test. The results showed the participants in both verbal and musical rehearsal conditions improved in language acquisition, as evidenced by an increase in scores between pre- and post-test. This finding indicates that musical rehearsal is just as effective and spoken rehearsal in
terms of learning vocabulary of another language. This finding also indicates that rehearsal, whether spoken or sung, plays a critical role in the recognition and acquisition of English vocabulary words by adult non-native English speakers.

Kamahara (2003) suggested that musical mnemonics facilitate language acquisition in non-native speakers because music provides structural elements that enable the ability to group information into meaningful units. Familiar melody also facilitates language acquisition because it provides retrieval cues that enable more efficient learning and recall of verbal information. Finally, verbal information that is presented as a song lyric is recalled more quickly and accurately (Kamahara, 2003).

Musical mnemonics can also facilitate the recall of unconnected text, or words that have no sentence structure or connection to each other. Some examples of unconnected text include word lists, names, or number combinations. Although little evidence supports the long-term effect of musical mnemonics on verbal recall, Rainey and Larson (2002) found that musical mnemonics could enhance long-term recall of unconnected text. The researchers conducted two experiments to examine the immediate and delayed recall of a word list comprised of unconnected verbal material. The participants were randomly assigned to a sung or spoken condition, in which the word list was either sung to the melody of “Pop Goes the Weasel,” or spoken without a musical accompaniment.

First, the participants listened while reading the word list along to the recording two times. Then the participants continued to listen to the recording without the visual aide, and were instructed to stop the recording when they were ready to recall the list. If the participants made an error during the recall, he or she continued to listen to the
recording until they could recite the list in order and without errors. The researchers recorded the total number of times each recording was heard. Significant differences between the sung and spoken versions were not observed in the initial learning session, indicating that musical and spoken rehearsals have equal effect on the immediate acquisition of unconnected verbal material.

The second session was conducted one week later, in which the participants were asked to recall the words from the list learned in the prior week without hearing the recording. If the participants were unable to recall the word list, the researchers implemented the same protocol from the first session using the word list from the previous week. The researchers recorded the total number of times the participants listened to the recording until the word list was “relearned” and could be recalled without errors. The results showed that the participants in the sung condition relearned the word list significantly faster than the participants in the spoken condition. This finding indicates the long-term effect of musical mnemonics on the maintenance and retention of unconnected and newly-learned text.

The second experiment was identical to the first experiment, except for the addition of a third condition, in which visual cues were presented to the participants without an auditory stimulus. The results showed that the participants in the visual condition required significantly fewer trials than the spoken or sung conditions in the first, or initial learning session. The results also showed that the participants in the sung condition required significantly fewer trials to relearn the word list than the spoken or
visual conditions in the second, or relearning session. These findings again show the effect of musical mnemonic on the maintenance and long-term storage of unconnected and unfamiliar verbal information.

The researchers suggest that the participants in the sung condition performed significantly better in the second session of both experiments because the participants may have automatically rehearsed the word list throughout the week whenever the melody came to mind. Therefore, the melody may have prompted rehearsal. The researchers also suggest that the familiar melody may have served as a retrieval cue during the recall tasks.

Research provides evidence that supports the effect of musical mnemonic on the short-term and long-term maintenance and storage of verbal information. Musical mnemonic can enhance the short-term recall of lyrical information, as well as the long-term recall of unconnected text. The findings in these studies show that music can be used as an effective learning tool in healthy populations. Therefore, researchers have also investigated the effect of musical mnemonic on verbal memory in clinical populations, in which memory impairments are evident.

**Clinical applications of musical mnemonic.** Researchers have investigated the effect of musical mnemonic on verbal recall in clinical populations including learning disabilities (Claussen & Thaut, 1997; Gfeller, 1983), multiple sclerosis (Moore, Peterson, O’Shea, McIntosh, Thaut, 2008; Thaut, Peterson, Sena, & McIntosh, 2008), and Alzheimer’s disease (Simmons-Stern, Budson, & Ally, 2010).

Gfeller (1983) conducted two experiments to examine the effect of musical mnemonic on short-term verbal recall in children with learning disabilities. The purpose
of the first experiment was to investigate the immediate effect of spoken and musical rehearsal on verbal recall. The participants were randomly assigned to one of two rehearsal conditions: spoken or musical. First, the researcher administered a pre-test, which provided baseline data regarding knowledge of multiplication problems. Then the researcher implemented a single rehearsal of the memory task, and a posttest.

The rehearsal of the memory task included several steps, in which the participants listened to a spoken or sung recording of a multiplication problem, repeated the problem out loud, wrote the answer down, and repeated the problem once more. Nine multiplication problems were presented. Each multiplication problem was sung to an unfamiliar melody in the musical rehearsal condition. The researchers then administered a post-test to compare scores with the pre-test.

The results showed that the participants with learning disabilities performed significantly poorer than the participants without learning disabilities in both verbal and sung conditions. The results also showed that the spoken rehearsal was significantly more effective than the musical rehearsal in both groups. These findings indicate that children with learning disabilities exhibit a verbal memory deficit, and that spoken rehearsal was more effective in an immediate recall task. The results also indicate that a single presentation of information sung to an unfamiliar melody is an ineffective technique because the participants were unable to gain familiarity with the musical structure and patterns. Additionally, the combination of unfamiliar verbal information sung to a novel melody may have caused cognitive overload during the learning processes, thus facilitating an adverse effect of musical mnemonics on short-term verbal memory.
The second experiment examined the effect of teaching method, extended rehearsal time, and rehearsal mode on recall. Participants were randomly assigned to one of three teaching method groups: posttest only, repetition only, and repetition with modeling and cueing (Gfeller, 1983). The same memory task (music and spoken) was implemented from the first experiment, except the participants in the repetition only and repetition with modeling and cueing groups attended four additional rehearsal sessions spaced over a three-day period. All three teaching method conditions included a post-test after each rehearsal. The post-test only group did not rehearse across the four treatment sessions.

The results revealed that the participants with and without learning disabilities in the repetition with modeling and cueing group recalled significantly more words following the musical rehearsal. This finding means that the combination of musical rehearsal with modeling and cueing is a beneficial learning tool for individuals with and without learning disabilities. Additionally, the participants in both repetition groups recalled significantly more information than those in the post-test only group. This finding indicates the significance of repetition on verbal recall, as well as the significant effect of pairing a visual aide with auditory rehearsal. Therefore, children with learning disabilities would greatly benefit from repetitive practice through music and guided instruction.

Claussen and Thaut (1997) also examined the effect of musical mnemonics on short-term verbal recall in children with learning disabilities. The participants were randomly assigned to a verbal rehearsal or musical rehearsal condition. The participants in the verbal rehearsal condition listened to a spoken recording of multiplication tables
and answers, and the participants in the musical rehearsal condition heard the same information sung to a familiar melody. Flash cards were shown during the musical and spoken rehearsals.

The participants listened and repeated out loud along with a sung or spoken recording of four multiplication tables. Then the participants wrote down the answer to each multiplication problem on an index card, which included the correct answer on the other side. The participants checked their responses for accuracy, and corrected each mistake. Then, the participants listened and repeated out loud along with the recording again. The rehearsal protocol was repeated using another set of multiplication tables, for a total of eight multiplication problems.

A post-test was then administered, which required the participants to answer the eight multiplication problems that were rehearsed in the presentation. The scores in the post-test were compared to the scores in the pre-test, which was given prior to the intervention to determine a knowledge base. The results showed that participants in the musical condition recalled significantly more accurate information than the participants in the verbal condition, indicating greater improvements in verbal memory through musical rehearsal.

Claussen and Thaut (1997) offered several reasons explaining their findings. First, the music enabled the participants to learn the new verbal information by pairing it with already-learned musical information. Second, the participants may have responded favorably to the musical mnemonic because of its novelty. Third, the addition of music may have stimulated higher attention processes because it was a different learning method, which made the participants more interested. Fourth, the temporal structure of
music may have influenced the organization of information into groups, thus enabling the participants to chunk the information into units that made verbal learning more efficient. Last, each multiplication fact was sung to the same melody, which established a redundant repetition of the melodic and rhythmic components. The redundancy may have also facilitated the ability to chunk the information. Therefore, musical mnemonics are effective learning tools used to improve verbal memory in children with learning disabilities.

The effect of musical mnemonics has also been examined in other clinical populations who experience memory deficits, including multiple sclerosis. Individuals with multiple sclerosis experience deficits in the initial learning of information, in addition to long-term memory impairments (Chiaravalloti & DeLuca, 2008). Moore et al. (2008) investigated the effect of musical mnemonics on verbal recall in adults with multiple sclerosis, in which participants were randomly assigned to a spoken or musical rehearsal group. Two word lists (List A and List B) were presented in a spoken or sung format. The word list was sung to the melody of “Skip to My Lou” in the musical rehearsal group, and spoken without an auditory stimulus in the spoken rehearsal group.

First, the participants learned a word list (List A) across 10 listening trials. Then, the participants heard and recalled another word list (List B) one time, followed by an immediate recall of List A. After a 20-minute distractor task, the participants were asked to recall the words from List A again. The participants were then given a recognition test, in which the participants listened to a presentation of 50 words and were asked to identify if each word was from List A, List B, or neither. The results showed no statistically significant differences between participants in the musical and spoken rehearsal
conditions during the recognition task. Therefore, the researchers suggest that a recognition test is not an ideal method to assess the effect of music on learning and memory. The results also showed that the participants with milder symptoms of multiple sclerosis performed significantly better than those with more severe symptoms of multiple sclerosis. This finding shows that musical mnemonics can be a helpful tool in learning verbal information in the earlier stages of multiple sclerosis. Other researchers have also investigated and shown the positive effect of music on verbal memory in adults with multiple sclerosis.

Thaut, Peterson, and McIntosh (2008) investigated the effect of musical mnemonics on verbal memory, and found that participants with multiple sclerosis were able to recall words in significantly better order following a musical rehearsal than a spoken rehearsal. The researchers offer two reasons that explain how the music may have facilitated better recall of word order. First, the music provides redundancy and temporal structure that enable the listeners to chunk information into meaningful groups. Second, the music provides rhythmic elements that enable the ability to chunk information, which may be a result of improved timing in deteriorating neural networks caused by symptoms of multiple sclerosis. This recruitment of neural activations shows the effect of music on brain plasticity, which is characterized by increased synchrony in learning-related networks (Thaut et al., 2005). Higher volume of neural synchronization may produce better neural traces for LTM and improved access to verbal knowledge for individuals with multiple sclerosis (Thaut et al., 2005). Therefore, music can effectively facilitate verbal learning and recall in individuals who experience mild symptoms of multiple sclerosis, in addition to the ability to recall words in order.
One final clinical population that has been examined using music as a learning device is Alzheimer’s disease. Simmons-Stern, Budson, and Ally (2010) investigated the effect of music on the recognition of newly-learned lyrical information in healthy adults and adults with mild Alzheimer’s disease. Each participant listened and read along silently to a presentation of 40 unfamiliar children’s songs; 20 were sung and 20 were spoken. Each song was presented two times. The researchers then administered a recognition task, in which 80 song lyrics were presented in a spoken format without musical accompaniment, including the 40 song lyrics from the presentation and 40 new song lyrics. The participants were asked to identify which lyrics were old or new.

The results showed that the participants with Alzheimer’s disease recognized the sung lyrics significantly more accurately than the spoken lyrics. Furthermore, the participants were able to recognize the sung lyrics when they were presented in a spoken format. The results also showed no significant difference in recognition of the sung or spoken lyrics in the healthy participants. These findings indicate that adults with Alzheimer’s disease utilize different encoding and retrieval processes for musical information than healthy individuals.

The researchers suggest several explanations underlying their results. First, music processing involves a neural network that recruits from multiple areas of the brain (Simmons-Stern et al., 2010). Therefore, lyrical information is better processed through musical stimuli because more areas of the brain become active, thus compensating for networks that are impaired, such as the hippocampus. Second, the temporal structure of the music produces improved timing and synchrony of neuronal firing, which facilitates encoding and retrieval processes (Simmons-Stern et al., 2010; Thaut et al., 2005). Finally,
the researchers suggest that the musical stimulus may have produced heightened arousal and attention in the participants with Alzheimer’s disease, resulting in better encoding processes and recognition of the lyrics that were sung than spoken.

These studies provide evidence that support the effect of music as a mnemonic device on verbal learning and recall in children with Learning Disabilities and adults with multiple sclerosis, in addition to the recognition of verbal information in older adults with Alzheimer’s disease. Musical mnemonics can help improve verbal memory abilities in clinical populations because it provides redundancy, heightened level of arousal, temporal structure that facilitates chunking and improved timing of neuronal firing, and an associative framework that links new verbal material with familiar musical information. The effect of music on verbal memory as it relates to cognitive processes and development has also been investigated. Recent research indicates that musical training may improve verbal memory as evidenced by neuroanatomical and behavioral findings.

Musical training and verbal memory. Researchers have found significant results regarding the effect of musical training on verbal recall (Chan et al., 1998; Franklin et al., 2008; Ho et al., 2003; Jakobson et al., 2008). The effect of musical training on verbal memory in children and adults has been explored in several studies. Ho et al. (2003) conducted a cross-sectional and longitudinal study to investigate the effect of musical training on verbal memory in children. The researchers aurally presented a word list three times to the participants, who were asked to recall as many words as possible after each trial. Verbal memory was then measured by administering a 10-minute and 30-
minute delayed recall trial. Results indicated that the children who received musical training recalled significantly more words than the children without musical training in both recall tasks.

The longitudinal study was conducted one year later, which included the same participants and procedure from the first experiment. The participants were assigned to one of three groups: those who had received musical training prior to the first experiment and continued leading up to the second, those who began musical training prior to the first experiment but discontinued nine months before the second, and those classified as “beginners” who began musical training after the first experiment was completed.

The researchers found that both groups of participants who began musical training prior to the first experiment achieved significantly greater recall scores than the beginner group. Although the participants who discontinued musical training nine months prior to the second experiment achieved significantly greater verbal recall scores than the beginner participants, the results also showed there were no improvements since the first experiments. In other words, the verbal memory abilities were maintained in the group that discontinued music lessons, as evidenced by no significant differences between the first and second experiment. However, significant improvements were observed in the beginner group and participants who continued musical training, which indicates the beneficial immediate and long-term effect of musical training on verbal memory. Musical
training can help maintain verbal memory abilities in individuals who discontinue
musical training, and can help improve verbal memory abilities in individuals who are
actively receiving musical training.

The long-term effect of childhood musical training on verbal memory has also
been investigated in young adults (Chan et al., 1998). Individuals who received up to six
years of musical training by the age of 12 and individuals without musical training
participated in the study. A word list was heard three times, in which the participants
were asked to recall and write down as many words as possible after each presentation.
The results showed that the participants with musical training recalled significantly more
words in all three trials compared to those without training. This finding indicates the
residual and long-term effect of early musical training on verbal memory skills.
Researchers have also investigated the effect of musical training on verbal memory in
individuals who continued to perform and/or study music throughout their childhood into
adulthood.

Jakobson et al. (2008) compared the verbal and visual memory performance
between young adult non-musicians and highly trained musicians. Non-musicians
reported to have had less than one year of private music lessons, or less than two years of
self-taught instruction. Musicians completed a high level of performance ability and
began formal musical training before the age of nine years.

To assess verbal memory, the researchers administered the California Verbal
Learning Test-II (CVLT-II), which measures immediate and delayed free verbal recall
(Delis, Kramer, Kaplan & Ober, 2000). The researchers aurally presented a word list
(List A) in five trials. After each trial, the participants were asked to recall and write
down as many words as possible. Then, the researchers presented another word list (List B) one time, and the participants were asked to recall as many words as possible. A short-free and short-cued recall task was then implemented, in which the participants recalled the words from List A. The words in List A were grouped into several different categories, which served as the cue during the cued recall task. Another test, the Rey Visual Design Learning Test (RVLDT), was administered for 20 minutes to assess visual memory (Graves & Sarazin, 1985). The participants were then given a long delay-free and long delay-cued recall task when the RVLDT was completed, in which the participants recalled the words from List A again.

The results showed an overall improvement in verbal recall between both musicians and non-musicians after the third trial. This finding indicates the value of repetition and rehearsal on verbal memory. The researchers also found significantly better performance in the musicians during the short-cued, long delay-free, and long delay-cued recall tasks, which indicates the effect of musical training on short and long-term verbal memory. The researchers suggest that musicians may perform better in verbal memory tasks because they encode semantic, or verbal information, more effectively than non-musicians.

Franklin et al. (2008) found consistent results regarding the effect of musical training on verbal memory in young adults. The experiment included two phases. In Phase 1, the participants listened to, and recalled words from List A five times. Then a second list (List B) was presented one time, and the participants were asked to recall as many words as possible. Then the participants were asked to recall the words from List A again. Thirty minutes later, a delayed-recall task was administered, in which the
participants recalled the words from List A one last time. Finally, the researchers administered a recognition test, in which all the words from Lists A and B were presented. The participants were asked to identify the words that belonged to List A. The results showed that the musicians recalled significantly more words than non-musicians in all immediate and delayed-recall tasks.

The same test was then implemented in Phase 2, with the addition of articulatory suppression, in which the participants were asked to say “the” before each word during the recall tasks. Articulatory suppression was used to prevent the rehearsal and transfer of the verbal information to memory. The researchers investigated the effect of articulatory suppression on verbal memory to determine if the significant differences between the musicians and non-musicians in Phase 1 were due to superior encoding strategies or greater general storage.

The results of Phase 2 showed contrary evidence to Phase 1. The inclusion of articulatory suppression produced insignificant results between the musicians and non-musicians. In other words, the musicians and non-musicians produced similar results on all recall tasks under articulatory suppression. The researchers suggest that the addition of articulatory suppression prevented the musicians from exercising a rehearsal, or encoding, strategy that may have been utilized during Phase 1, in which verbal recall was significantly greater in musicians than non-musicians.

The findings in Phases 1 and 2 indicate that, in natural verbal learning settings (i.e., without articulatory suppression), musicians utilize rehearsal skills that non-musicians lack during verbal learning and memory processes. The results indicate that musical training might enhance the rehearsal mechanisms that are used during verbal
learning and memory tasks (Franklin et al., 2008). However, these mechanisms, which are mediated by the left temporal area in musicians, have yet to be determined (Ho et al., 2003).

**Summary of mediating effects of music and verbal memory.** Music has a significant effect on verbal memory through musical mnemonics and musical training. Researchers have shown that music can be used as an effective learning tool in populations with and without clinical diagnoses. Music can facilitate verbal learning and recall because it contains structural elements, such as melody and rhythm that enable the chunking of verbal information into meaningful units, and provides retrieval cues. Furthermore, familiar music may facilitate verbal learning because it provides an associative framework that links musical and verbal information together.

Musical mnemonics can help improve the short-term recall of lyrical text and the long-term retention of unconnected text in healthy populations. Musical mnemonics can also facilitate verbal memory and recognition in populations who experience memory deficits, including learning disabilities, multiple sclerosis, and Alzheimer’s disease.

Researchers have also found that individuals with musical training tend to perform significantly better in verbal memory tasks compared to those without training. Researchers offer several explanations underlying the significant differences between musicians and non-musicians. First, musicians may utilize better rehearsal strategies during verbal learning and memory processes. Second, neuroanatomical evidence shows bi-hemispheric activation during verbal and tonal working memory tasks in musicians compared to non-musicians. Last, several areas that are associated with language
processing, such as the left PT, showed greater left hemispheric activation in musicians than non-musicians during music listening. These findings indicate distinct and overlapping activations associated with music and verbal memory.

These studies provide evidence that support the effect of musical mnemonics on verbal memory in healthy and clinical populations, as well as the effect of musical training on verbal memory in healthy individuals. However, there is a paucity of research that examines the combined use of musical mnemonics and musical training on verbal memory. Therefore, this study will investigate the combined effect of both musical training and musical mnemonics on verbal memory in young adults.

**Research questions.** The following research questions were addressed in this study:

1. What is the main effect of musical training on word recall in young adults?
2. What is the main effect of musical mnemonics on word recall in young adults?
3. What is the interaction effect of musical training and musical mnemonics on word recall of young adults?

**Null hypotheses.** The following null hypotheses were addressed in this study:

1. There is no main effect of musicianship on word recall in young adults.
2. There is no main effect of mnemonic modality on word recall in young adults.
3. There is no interaction effect of musicianship and musical mnemonics on word recall in young adults.
Chapter 3

Method

This chapter will first discuss details regarding the participants in this study, including method of recruitment and eligibility criteria. Next, the design and variables will be identified, followed by a description of the materials and measures used to assess demographic information and word recall. This chapter will also describe, in detail, the protocol of the procedure that was used to assess word recall. Finally, this chapter will discuss how the data were collected and analyzed.

Participants

This study included 100 freshman students enrolled at the University of Miami who ranged in age from 18 to 23 years. The participants were recruited through classroom visitations, word of mouth, flyers posted throughout campus (see Appendix A), and web announcements. Participants who were enrolled in a psychology course were awarded credit for their participation.

Inclusion criteria. Only individuals who spoke English as their primary language were included in this study. Freshman students who were enrolled at the University of Miami were included in this study in order to maintain a constant age and level of education.

Musicians. Participants were considered musicians if they met all of the following criteria: a) began learning an instrument before the age of ten (Franklin et al., 2008), b) currently take formal instrumental or vocal lessons at the Frost School of
Music, c) practice or play their instrument at least 10 hours a week, and d) are majoring in music (Franklin et al., 2008). All musicians were also enrolled in at least nine credits of music classes.

**Non-musicians.** Participants were considered non-musicians if they a) received less than one year of private music lessons, or b) received less than two years of self-taught instruction (Franklin et al., 2008). All non-musicians reported to have had little to no musical skills, such as the ability to read music or play an instrument.

**Exclusion criteria.** Individuals who did not speak English as their first language were not included in this study.

**Design and Variables**

A 2x2 repeated measures between-subjects factorial design (Gravetter & Wallnau, 2011) was implemented in this study to examine the relationship between the independent variables, mnemonic modality (music and spoken) and musicianship (musicians and non-musicians), on the dependent variable of Word Recall. Word Recall was measured by a recall task, which was given throughout four trials.

**Measures**

**Demographic information.** Demographic information was collected in a two-part researcher-designed questionnaire (see Appendix B). Part I acquired information regarding age, gender, major/concentration, and level of musicianship. Part II of the questionnaire differed by the mnemonic condition. Thus, one version included questions that addressed the Musical mnemonic rehearsal, and the other version contained
questions pertinent to the Spoken rehearsal. Part II acquired narrative information regarding the use of learning strategies, the effectiveness of the rehearsal (music or spoken), and experiences or challenges during the recall tasks.

Participants in both conditions received Part I of the questionnaire. All participants in the Musical mnemonic condition received Part II of the questionnaire that addressed the effectiveness of the musical rehearsal. All participants in the Spoken condition received Part II of the questionnaire that addressed the effectiveness of the spoken rehearsal. Part I and II were completed at the end of each session.

**Word Recall.** Word recall was measured through a researcher-designed recall trial form (see Appendix C). The participants were instructed to listen to a recorded presentation of 14 words and asked to freely recall and write down as many words as they could remember on the form provided. Four recall trial forms were given in one session. Therefore, word recall was measured across four trials. The researcher scored the results by recording the number of correct words written. Each correct word received one point, while each correct word recalled in the correct order received two points. The total possible score was 28.

**Materials**

**Informed consent.** Prior to the study, the participants signed a letter of informed consent as required by the University of Miami Institutional Review Board, which provided information regarding the purpose of the study and procedure (see Appendix D).

**Recall trial forms.** The researcher provided each participant with a recall trial form (see Appendix C) that was administered four times. The recall trial forms include
Trial Recall 1, Trial Recall 2, Trial Recall 3, and Final Recall. The Final Recall measured the short-term effect of music or spoken rehearsal.

**Distraction task.** A distraction task (see Appendix E) was administered to interfere with rehearsal and maintenance of the verbal information over a short period of time. The participants were given 10 minutes to complete a mental arithmetic task, in which they were asked to count down by sevens from 1500. The participants were instructed to only write the values, and to do the math work in their heads. The distraction task enabled the researcher to determine if the verbal information was held in memory after the 10-minute delay.

**Word list.** The researcher created a list of 14 random SAT vocabulary words (see Table 1), which consisted of unconnected text (Rainey & Larson, 2002). In other words, the words had no sentence structure or relation to one another. The word list was recorded in a sung format to the familiar melody of “Yesterday” by The Beatles in the Musical mnemonic condition (see Appendix F). The word list was also recorded in a spoken format in the Spoken condition. The participants were given a printed hardcopy of the word list to use during each presentation.

**Table 1**

<table>
<thead>
<tr>
<th>Words</th>
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<tr>
<td>1. Abdicate</td>
<td>8. Capitate</td>
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<tr>
<td>3. Increment</td>
<td>10. Succinet</td>
</tr>
<tr>
<td>4. Ostensible</td>
<td>11. Florid</td>
</tr>
<tr>
<td>5. Circumspect</td>
<td>12. Incessant</td>
</tr>
<tr>
<td>6. Intrepid</td>
<td>13. Hapless</td>
</tr>
<tr>
<td>7. Whimsical</td>
<td>14. Eminent</td>
</tr>
</tbody>
</table>
Musical mnemonic. The use of a familiar melody is more effective than an unfamiliar melody when learning new information (Purnell-Webb & Speelman, 2008; Wallace, 1994). Familiar melodies provide a preexisting framework, which reduce cognitive overload when learning novel material (Claussen & Thaut, 1997). Familiar melodies also provide an associative link to the text (Chazin & Neuschatz, 1990). Therefore, the word list was sung to the familiar melody of “Yesterday” by The Beatles (see Appendix F), which was chosen because the natural prosody and syntax of the words fit the melodic and rhythmic phrasing of the song. Furthermore, other researchers have also used songs by The Beatles in previous research that investigated the effect of musical mnemonics on verbal learning with young adults (Kamahara, 2003).

The melodic structures of “Yesterday” utilize the Gestalt laws of perception including proximity, good continuation, common fate, and similarity through melodic, harmonic, and rhythmic elements. The melody of “Yesterday” is simple because it is sung in the key of E minor, with little chromatic changes, and consists of ascending and descending step-wise lines. The rhythm is also simple because it is in duple meter, or 4/4, and consists of basic quarter and eighth notes. Several areas are more complex, such as dotted quarter and eighth notes, however those rhythms are heard at the ends of phrases, which provide predictability in common fate.

The melodic range is limited bordering outside of an octave, from A3 to C5. The melody comprises several ascending and descending lines that provide good continuation and common fate, leading to the tonic note. The distance between the pitches in each phrase are close in proximity, creating intervals that lay within a whole step, major third, perfect fourth, or perfect fifth. The proximity between the pitches enables the listener to
perceive and group the information into single, more meaningful units (Deutsch, 1999).

The direction of the cadence follows the common fate law of perception because it facilitates predictability by leading the melody to a resolved tonic chord. Finally, good continuation and similarity are evident in the melodic and rhythmic phrases, which provide repetitive patterns that chunk the 14 items of information into five meaningful units. Each phrase is sung two times during each presentation, thus providing redundancy through repetition which may facilitate the ability to chunk information (Claussen & Thaut, 1997; Thaut et al., 2008).

The melody and rhythm match the natural prosody of each word, and provides a structured and organized presentation of the verbal information. The melody was sung at a tempo of 60 beats per minute in order to provide clarity of each syllable and word.

**Audio recording.** The researcher created two audio recordings using Garage Band© on a Macbook Pro© laptop. One recording was for the Musical mnemonic condition, and one for the Spoken condition. The researcher used recordings to account for consistent presentations of the sung or spoken word list in each session. A University of Miami female mezzo-soprano vocal student recorded both sung and spoken presentations. An accompaniment was not included in the sung recording because the researcher wanted the participants to focus primarily on the words sung to the melody.

The vocalist sang the word list to the melody of “Yesterday” for the Musical mnemonic condition. The natural timing and prosody of the words were preserved in the musical mnemonic. The tempo of “Yesterday” was set to 60 beats per minute. In the Spoken condition, the vocalist verbally stated each word from the same word list at one word per second. The natural timing and prosody of the words were also preserved in the
spoken presentation, and presented at 60 words per minute. Therefore, the words were presented at the same tempo in both sung and spoken recordings.

**Audio equipment.** The researcher used a program called Garage Band© through an Apple MacBook Pro© to record the spoken and sung presentations of the word list. The researcher presented the spoken or sung recording to the participants using iTunes© through the Apple MacBook Pro© laptop built-in speakers, which was played at an audible volume.

**Procedure**

Half of the participants (n=50) were non-musicians, and the other half (n=50) were musicians. Twenty-five musicians were randomly assigned to the Musical Mnemonic condition, and the other 25 to the Spoken condition. Twenty-five non-musicians were randomly assigned to the Musical Mnemonic condition, and the other 25 to the Spoken condition. The participants met with the researcher one time for approximately 30 minutes. Each participant received only one condition: Spoken or Musical Mnemonic.

The researcher met with the participants in rooms in the Otto G. Richter Library and Marta and Austin Weeks Music Library, which are located on the University of Miami campus. Meetings were held individually and in groups, based on availability and scheduling. Groups included up to six participants. The researcher began each session with a short introduction to the study, then provided an informed consent form for each student to review and sign (see Appendix D).

Following written permission, the researcher provided each participant with a paper that remained face down, which consisted of the word list (see Appendix G). The
participants were instructed to read the word list only during either mnemonic presentation. The list was not read or used as a reference during the recall tasks.

During each recall trial, the participants were asked to freely recall and write down as many words as possible on each trial recall form. The participants were also encouraged to write down as many words in the order they were originally presented.

Each session followed a protocol similar to previous research (Purnell-Webb & Speelman, 2008; Wallace, 1994) in which five trials and a distraction task were implemented in one session.

In Trial One, the participants:

1) listened and silently read along to the recording one time
2) recalled and wrote down as many words as possible in 3 minutes

In Trial Two, the participants:

3) listened and silently read along to the recording one time
4) recalled and wrote down as many words as possible in 3 minutes after listening

In Trial Three, the participants:

5) listened and silently read along with recording one time, with no recall task

In Trial Four, the participants:

6) listened and silently read along with the presentation one last time
7) recalled and wrote down as many words as possible in 3 minutes after listening

In Trial Five, the participants:

8) completed the distraction task in 10 minutes
9) recalled and wrote down as many words as possible in 3 minutes
The total time to complete the five trials was approximately 25 minutes. Participants then completed the demographic questionnaire, which took approximately five minutes. The entire session lasted 30 minutes.

**Data Collection**

Data were collected by scoring each recall form in Trials One, Two, Four, and the Final Recall. The researcher scored each correct word with one point and each correct word in the correct order with two points. The total possible score was 28. The scoring enabled the researcher to determine the effect of music or spoken rehearsal on word recall. The final recall form enabled the researcher to observe the short-term effect of music or spoken rehearsal on the preservation of verbal information following a 10-minute distraction task. The recall trials also enabled the researcher to investigate 1) word recall between musicians and non-musicians, 2) the effect of musical mnemonics on word recall in musicians compared to non-musicians, and 3) the difference in word recall following a musical mnemonic or spoken rehearsal among musicians.

**Data Analysis**

Data were analyzed using a 2x2 repeated measures analysis of variance (ANOVA) to investigate the effect of musical mnemonics on word recall in musicians and non-musicians. Two factors were examined. The first factor consisted of the group, which included two levels: Musicians and Non-musicians. The other factor was the condition, which also includes two levels: Musical mnemonic and Spoken. The dependent variable is the continuous variable of Word Recall. Assumptions of the
ANOVA were checked before running the model, including normality of the Word Recall variable, and homogeneity of variance within the groups (although a violation might not be a concern because of equal group sizes).

Two main effects were examined in this study, including musicianship and mnemonic modality, which answered research questions one and two, respectively. An interaction effect between the two factors was also examined to answer research question three. Specifically, this interaction tested if the effect of Musical mnemonics on Word Recall was different for Musicians and Non-musicians.
Chapter 4

Results

In this chapter, statistical analysis of the data will be discussed. A 2x2 repeated measures factorial design was used to examine whether the independent variables of musicianship and mnemonic modality would have an effect on the dependent variable of word recall. The independent variable of musicianship consisted of two groups: Musicians and Non-musicians. The other independent variable of mnemonic modality consisted of two conditions: Musical mnemonic and Spoken. The dependent variable of word recall was measured by scoring each correct word with one point and each correct word in the correct order with two points. The total possible score was 28. Word Recall was measured throughout four trials.

The results of the descriptive analyses are reported first, followed by results of the inferential statistics. The results are organized by research question. Descriptive results are provided and include the participants’ demographic information, in addition to the mean scores of all four trials between the two groups and two conditions. The inferential results of the participants are presented next. Performances on verbal recall were analyzed using a repeated measures analysis of variance (ANOVA), which determined if significant differences existed across four trials of measurement between musicians and non-musicians following a musical mnemonic or spoken rehearsal.

The first research question investigated the effect of musicianship on verbal recall in young adults. The second question investigated the effect of musical mnemonics on verbal recall in young adults. The final question examined the interaction effect of
musicianship and musical mnemonics on verbal recall in young adults. The researcher met with the participants one time for 30 minutes, in which recall was measured across four trials.

**Descriptive Results**

In this section, participants’ demographic information and responses to the Demographic Questionnaire are described, which includes information regarding age, gender, major/concentration, and musical training. Additionally, the participants’ verbal recall scores in each trial are provided between and within groups (musicians and non-musicians) and conditions (Spoken and Musical mnemonic).

**Participants.** A total of 100 freshman students enrolled at the University of Miami participated in this study. Of the 100 participants, 43 were male and 57 were female; 50 were musicians, and 50 were non-musicians. The mean age was 18.25 ($SD = 2.66$) with participants ranging from 18 to 23 years old. Of the 100 participants, 50 were enrolled in the Frost School of Music, and the other 50 participants were enrolled in eight different colleges (see Table 2).

Of the 50 musicians, 12 studied Music Therapy, seven Instrumental Performance, nine Vocal Performance, five Studio Music and Jazz Instrumental Performance, two Studio Music and Jazz Vocal Performance, five Music Business, four Music Engineering, five Music Education, and one Composition. The average daily number of hours of music listening among the 100 participants was 3.55 hours ($SD = 2.10$). Detailed demographic information is listed in Table 2.
Table 2

*Frequency of Participant Demographics*

<table>
<thead>
<tr>
<th>Demographic Variables</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>43</td>
<td>43%</td>
</tr>
<tr>
<td>Female</td>
<td>57</td>
<td>57%</td>
</tr>
<tr>
<td>Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Musician</td>
<td>50</td>
<td>50%</td>
</tr>
<tr>
<td>Non-musician</td>
<td>50</td>
<td>50%</td>
</tr>
<tr>
<td>Age (in years)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>81</td>
<td>81%</td>
</tr>
<tr>
<td>19</td>
<td>17</td>
<td>17%</td>
</tr>
<tr>
<td>21+</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Majors/Concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>School of Architecture</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>School of Business Administration</td>
<td>8</td>
<td>8%</td>
</tr>
<tr>
<td>College of Arts and Sciences</td>
<td>21</td>
<td>21%</td>
</tr>
<tr>
<td>School of Communication</td>
<td>3</td>
<td>3%</td>
</tr>
<tr>
<td>College of Engineering</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Rosenstiel School of Marine and Atmospheric Science</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Frost School of Music</td>
<td>50</td>
<td>50%</td>
</tr>
<tr>
<td>School of Nursing and Health Studies</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>School of Education and Human Development</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Undecided</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Music Majors/Concentrations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Music Therapy</td>
<td>12</td>
<td>12%</td>
</tr>
<tr>
<td>Instrumental Performance</td>
<td>7</td>
<td>7%</td>
</tr>
<tr>
<td>Vocal Performance</td>
<td>9</td>
<td>9%</td>
</tr>
<tr>
<td>Studio Music &amp; Jazz Instrumental Performance</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Studio Music &amp; Jazz Vocal Performance</td>
<td>2</td>
<td>2%</td>
</tr>
<tr>
<td>Music Business</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Music Engineering</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>Music Education</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>Composition</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Daily average of music listening (in hours)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 1</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>1 - 1.5</td>
<td>26</td>
<td>26%</td>
</tr>
<tr>
<td>2 - 2.5</td>
<td>18</td>
<td>18%</td>
</tr>
<tr>
<td>3 - 3.5</td>
<td>20</td>
<td>20%</td>
</tr>
<tr>
<td>4 - 4.5</td>
<td>12</td>
<td>12%</td>
</tr>
<tr>
<td>5 - 5.5</td>
<td>7</td>
<td>7%</td>
</tr>
<tr>
<td>6 - 6.5</td>
<td>4</td>
<td>4%</td>
</tr>
<tr>
<td>More than 7</td>
<td>8</td>
<td>8%</td>
</tr>
</tbody>
</table>
Musical training of each musician participant was examined in further detail. Of the 50 musicians, four played piano, five played string instruments, nine played brass instruments, nine played woodwind instruments, three played guitar, and 20 were vocalists. Seven of the musicians reported to have played their instruments 4-6 years, 14 for 7-9 years, 23 for 10-13 years, and six for 14-16 years. The mean number of years playing a musical instrument was 10.70 ($SD = 2.79$).

Seven musicians reported to have taken 0 to 3 years of formal music lessons, 14 for 4-6, 10 for 7-9, 15 for 10-13, and four for 14 to 16 years. The mean number of years receiving formal music lessons was 7.96 ($SD = 3.89$). Forty musicians did not receive self-taught music lessons. The other 10 musicians received 4 to 13 years of self-taught music instruction. The mean number of years of self-taught musical instruction was 1.87 ($SD = 3.09$).

Two musicians currently reported that they play their instrument 1 to 5 hours weekly, 16 play 6 to 10 hours, 15 play 11 to 15 hours, and 17 play more than 16 hours weekly. Finally, 20 musicians began playing their instrument between ages 3 and 6, 20 musicians began between ages 7 and 10, and 10 began between ages 11 and 14. The mean age the musicians began to learn to play a musical instrument was 7.59 years old ($SD = 2.66$). Of the 50 musicians, 26% did not fully meet the study criteria as a musician. However, due to lack of volunteers, the researcher allowed participants who met three out of the four requirements to participate as a musician. All musicians were music majors and reported to be currently taking formal lessons. Detailed musicians’ responses regarding musical training is listed in Table 3.
Table 3

Frequency, Means, Standard Deviations, and Range of Musicians’ Musical Training

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instruments Played</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Piano</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strings</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brass</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodwind</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voice</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guitar</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of Years Played (in years)</strong></td>
<td>10.70</td>
<td>2.79</td>
<td>3 – 15</td>
<td></td>
</tr>
<tr>
<td>4 – 6</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 – 13</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 – 16</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Formal Music Lessons (in years)</strong></td>
<td>7.96</td>
<td>3.89</td>
<td>2 – 15</td>
<td></td>
</tr>
<tr>
<td>0 – 3</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – 6</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 – 13</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 – 16</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Self-taught Music Lessons (in years)</strong></td>
<td>1.87</td>
<td>3.09</td>
<td>0 - 13</td>
<td></td>
</tr>
<tr>
<td>0 – 3</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – 6</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 – 13</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average Daily Practice Time (in hours)</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>1 – 5</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 – 10</td>
<td>16</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 – 15</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 +</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Age Musical Training Began (in years)</strong></td>
<td>7.59</td>
<td>2.66</td>
<td>3 – 12</td>
<td></td>
</tr>
<tr>
<td>3 – 6</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 10</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 – 14</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Word Recall.** The descriptive results, shown in Table 4, include means and standard deviations of word recall scores in each recall trial for musicians and non-musicians in the Musical mnemonic and Spoken conditions. For each recall trial, participants could receive a score ranging from 1 to 28, with 1 indicating the lowest score and 28 indicating a total possible score. For all trials, no participants scored less than 1.

In the Musical mnemonic condition, five musicians scored a 28 in Trial 3 and four musicians scored a 28 in the Final Recall. Two non-musicians scored a 28 in Trial 3 and in the Final Recall. In the Spoken condition, three musicians scored a 28 in Trial 3; and one non-musician scored a 28 in Trial 3 and in the Final Recall.

The first section of Table 4 includes scores from the Spoken condition, and the second section of the table includes scores from the Musical mnemonic condition. The table also includes the mean and standard deviation of the total word recall scores for all participants in each condition. The non-musician and musician participants achieved their highest average scores in the third trial in both Spoken and Musical mnemonic conditions. In Trial 3, the musicians’ highest mean score was 17.92, and the non-musicians’ highest mean score was 17.28 in the Spoken condition. In Trial 3, the musicians’ highest score was 19.76, and the non-musicians’ highest score was 16.68 in the Musical mnemonic condition.

The results also show an increase in average scores from Trial 1 to Trial 2, followed by a further increase in Trial 3, and then a small decrease in scores from Trial 3 to the Final Recall Trial. However, the scores in the Final Trial remained greater than the
scores in Trials 1 and 2, indicating retention of verbal information over a short time period. The mean total scores between both groups and both conditions are depicted in the form of a line graph in Figure 1.

![Line graph showing verbal recall scores across trials for non-musicians and musicians in Spoken and Musical mnemonic conditions.](image)

**Figure 1.** Mean Total Scores Across Trials.

The mean scores of the non-musicians across trials in the Spoken and Musical mnemonic condition are depicted in Figure 2. The non-musicians achieved their highest average scores in the third trial of both conditions. In Trial 3, the non-musicians’ highest mean score of 17.28 was in the Spoken condition, and 16.68 in the Musical mnemonic condition. The figure illustrates an upward trend across the first three trials, and a downward trend in the final recall, which followed the distraction task. Overall, the non-musicians’ highest score was observed in the Spoken condition.
### Table 4

**Means and Standard Deviations of Verbal Recall Scores**

<table>
<thead>
<tr>
<th></th>
<th>Non-Musician</th>
<th></th>
<th>Musician</th>
<th></th>
<th>Total Score</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td><strong>Spoken Condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1</td>
<td>7.64</td>
<td>3.17</td>
<td>9.08</td>
<td>2.98</td>
<td>8.36</td>
<td>3.08</td>
</tr>
<tr>
<td>Trial 2</td>
<td>12.64</td>
<td>4.96</td>
<td>13.60</td>
<td>4.46</td>
<td>13.12</td>
<td>4.71</td>
</tr>
<tr>
<td>Trial 3</td>
<td>17.28</td>
<td>6.26</td>
<td>17.92</td>
<td>5.64</td>
<td>17.60</td>
<td>5.95</td>
</tr>
<tr>
<td>Final Recall</td>
<td>14.76</td>
<td>6.92</td>
<td>16.44</td>
<td>6.18</td>
<td>15.60</td>
<td>6.55</td>
</tr>
<tr>
<td><strong>Musical mnemonic Condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trial 1</td>
<td>7.52</td>
<td>3.31</td>
<td>8.12</td>
<td>3.49</td>
<td>7.82</td>
<td>3.4</td>
</tr>
<tr>
<td>Trial 2</td>
<td>12.32</td>
<td>5.51</td>
<td>13.00</td>
<td>5.20</td>
<td>12.66</td>
<td>5.36</td>
</tr>
<tr>
<td>Trial 3</td>
<td>16.68</td>
<td>6.31</td>
<td>19.76</td>
<td>6.61</td>
<td>18.22</td>
<td>6.46</td>
</tr>
<tr>
<td>Final Recall</td>
<td>14.60</td>
<td>6.73</td>
<td>17.52</td>
<td>6.90</td>
<td>16.06</td>
<td>6.82</td>
</tr>
</tbody>
</table>
Figure 2. Non-musicians’ Mean Word Recall Scores Across Trials.

The mean scores of the musicians across trials in the Spoken and Musical mnemonic condition are depicted in Figure 3. The musicians achieved their highest average scores in the third trial of both mnemonic conditions. In Trial 3, the musicians’ highest score of 19.76 was in the Musical mnemonic condition, and 17.92 in the Spoken condition. The line graph illustrates an upward trend across the first three trials and a downward trend in the final recall trial. Overall, the musicians’ highest score was observed in the Musical mnemonic condition.

Figure 3. Musicians’ Mean Word Recall Scores Across Trials.
The results of the Musical mnemonic condition in both groups (musicians and non-musicians) are depicted in Figure 4. In the Musical mnemonic condition, the musicians recalled a greater number of words than the non-musicians in all four trials. An upward trend was observed over the first three trials and a downward trend in the final recall in both groups. The musicians’ and non-musicians’ highest scores were observed in the third trial. The highest score was 19.76 in the musician group, and the highest score was 16.68 in the non-musician group. In the final recall trial, the musicians scored 16.98, and the non-musicians scored 14.68.

*Figure 4.* Mean Word Recall Scores in the Musical mnemonic condition.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Verbal Recall</th>
<th>Musicians</th>
<th>Non-musicians</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.50</td>
<td>12.20</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>16.50</td>
<td>14.80</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>19.76</td>
<td>16.68</td>
<td></td>
</tr>
<tr>
<td>Final Recall</td>
<td></td>
<td>16.98</td>
<td>14.68</td>
</tr>
</tbody>
</table>

In the Spoken condition, the musicians also recalled more words than the non-musicians over all four trials. An upward trend was observed in the first three trials and a downward trend in the final recall. The musicians’ and non-musicians’ highest scores were observed in the third trial. The musicians’ highest score was 17.92, and the non-musicians’ highest score was 17.28. The results of the Spoken condition in both musicians and non-musicians are illustrated in Figure 5.
Figure 5. Mean Word Recall Scores in the Spoken condition.

The mean total scores between both groups (Musicians and Non-musicians) are depicted in the form of a bar graph in Figure 6. The musicians achieved greater mean scores than the non-musicians in all four trials. In Trial 1, the non-musicians’ mean total score was 7.58, and the musicians’ mean total score was 8.60. In Trial 2, the non-musicians’ mean total score was 12.48, and 13.30 in the musicians. In Trial 3, the non-musicians’ mean total score was 16.98, and 18.84 in the musicians. In the Final Recall trial, the non-musicians’ mean total score was 14.68, and 16.98 in the musicians. An upward trend is evident over the first three trials, followed by a downward trend in the final recall trial.
Finally, the mean total scores between conditions (Musical mnemonic and Spoken) are illustrated in the form of a bar graph in Figure 7. The results show that the participants in the Spoken condition recalled more words than participants in the Musical mnemonic condition in Trials 1 and 2. However, the participants in the Musical mnemonic condition recalled more words than the participants in the Spoken condition in the third and final trials. The highest scores were observed in the third trial of both conditions. The mean total score for participants in the Musical mnemonic condition was 18.22 in the third trial. The mean total score for participants in the Spoken condition was 17.60 in the Spoken condition in the third trial. Both conditions show an upward trend in the first three trials, and a downward trend is observed in the final trial.
Figure 7. Mean Total Word Recall Scores between Conditions for all Participants.

**Inferential Analysis Results**

A repeated measures ANOVA (Gravetter & Wallnau, 2011) was used to determine significant differences in recall scores between the groups and conditions. Two assumptions of repeated measures ANOVA were checked before the model was implemented. The assumption of normality of the Word Recall variable was inspected and met visually with histograms (see Figure 8), as well as through values of skewness and kurtosis (see Table 5). The assumption of homogeneity was tested with Box’s test of Equality of covariance matrices and met ($\chi^2(5) = .58, p = .967$). The assumption of sphericity was not met. Instead, the Huynh-Feldt adjustment was used, which corrected the degrees of freedom to yield desirable power (Gravetter & Wallnau, 2011). Additionally, Tables 6 and 7 show the results of the between- and within-subjects repeated measures ANOVA.
Table 5

*Means, Standard Deviations, Skewness, and Kurtosis of Variables*

<table>
<thead>
<tr>
<th></th>
<th>$M$</th>
<th>$SD$</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>8.09</td>
<td>3.25</td>
<td>.356</td>
<td>-.504</td>
</tr>
<tr>
<td>Trial 2</td>
<td>12.89</td>
<td>4.99</td>
<td>.358</td>
<td>-.667</td>
</tr>
<tr>
<td>Trial 3</td>
<td>17.91</td>
<td>6.23</td>
<td>.030</td>
<td>-1.01</td>
</tr>
<tr>
<td>Final Recall</td>
<td>15.83</td>
<td>6.70</td>
<td>.295</td>
<td>-2.04</td>
</tr>
<tr>
<td>Musicianship</td>
<td>1.50</td>
<td>0.50</td>
<td>.000</td>
<td>.000</td>
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<tr>
<td>Mnemonic Modality</td>
<td>1.50</td>
<td>0.50</td>
<td>.000</td>
<td>.000</td>
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</tbody>
</table>
Figure 8. Histogram of Word Recall Across Trials.
Table 6

**Repeated Measures Analysis of Variance (ANOVA) Within-Subjects**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials</td>
<td>543.76</td>
<td>3</td>
<td>1812.92</td>
<td>189.672</td>
<td>.001</td>
</tr>
<tr>
<td>Trials*Musicians</td>
<td>36.56</td>
<td>3</td>
<td>12.18</td>
<td>1.275</td>
<td>.283</td>
</tr>
<tr>
<td>Trials*Modality</td>
<td>27.44</td>
<td>3</td>
<td>9.14</td>
<td>0.957</td>
<td>.413</td>
</tr>
<tr>
<td>Trials<em>Musicians</em>Modality</td>
<td>41.48</td>
<td>3</td>
<td>13.82</td>
<td>1.447</td>
<td>.229</td>
</tr>
<tr>
<td>Error (trials)</td>
<td>2752.76</td>
<td>288</td>
<td>9.55</td>
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<td></td>
</tr>
</tbody>
</table>

Table 7

**Repeated Measures Analysis of Variance (ANOVA) Between-Subjects**

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
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<tr>
<td>Intercept</td>
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<td>1</td>
<td>74856.96</td>
<td>825.367</td>
<td>.001</td>
</tr>
<tr>
<td>Musicians</td>
<td>225.00</td>
<td>1</td>
<td>225.00</td>
<td>2.481</td>
<td>.119</td>
</tr>
<tr>
<td>Mnemonic Modality</td>
<td>0.04</td>
<td>1</td>
<td>0.04</td>
<td>.000</td>
<td>.983</td>
</tr>
<tr>
<td>Musicians*Mnemonic Modality</td>
<td>10.24</td>
<td>1</td>
<td>10.24</td>
<td>.113</td>
<td>.738</td>
</tr>
<tr>
<td>Error</td>
<td>8706.76</td>
<td>96</td>
<td>90.69</td>
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<td></td>
</tr>
</tbody>
</table>
Research Question #1: What is the main effect of musical training on word recall in young adults?

Null Hypothesis #1. There will be no main effect of musical training on verbal recall in young adults. This researcher failed to reject this null hypothesis. The repeated measures ANOVA indicated that there were no statistically significant differences between musicians and non-musicians, controlling for trials and mnemonic modality, $F(1, 96) = 2.481, p = 0.119, \eta^2 = .025$. Therefore, there was no main effect of musical training on word recall. Additionally, the strength of the relationship between musicians and non-musicians, as assessed by the partial eta square value, accounted for 2.5% variance in word recall after controlling for trials and mnemonic modality.

Research Question #2: What is the main effect of musical mnemonics on word recall in young adults?

Null Hypothesis #2. There will be no main effect of mnemonic modality (music or spoken) on verbal recall in young adults. This researcher failed to reject this null hypothesis. The repeated measures ANOVA indicated that there were no statistically significant differences between mnemonic modality conditions, controlling for trial groups, $F(1, 96) = .000, p = 0.983, \eta^2 = .000$. Therefore, there was no main effect of mnemonic modality on word recall. Additionally, the strength of the relationship between musical mnemonics and spoken rehearsal, as assessed by the partial eta square value, accounted for 0% of variance in word recall after controlling for trials and musicians.

Research Question #3: What is the interaction effect of musical training and musical mnemonics on word recall in young adults?
**Null Hypothesis #3.** There will be no interaction effect of musicianship and musical mnemonics on verbal recall in young adults. This researcher failed to reject this null hypothesis. The repeated measures ANOVA indicated that there was no statistically significant three-way interaction between musical training, trials, and mnemonic modality $F(3, 288) = 1.447, p = 0.229, \eta^2_p = .015$. This finding shows that the effect of musical training was not dependent on the trial of observation or the mnemonic modality. Therefore, there was no interaction effect of musical training, trials, and mnemonic modality on word recall. Additionally, the strength of the relationship of the interaction between mnemonic modality, musicianship, and trials, as assessed by the partial eta square value, accounted for 1.5 % of variance in word recall.

**Additional Findings.** In addition to comparing the differences and interaction between musicianship and mnemonic modality on verbal recall in young adults, this researcher examined the following question: What is the main effect of trials on verbal recall in young adults?

This researcher found a main effect of trials using a repeated measures ANOVA, which indicated significant differences between trials, controlling for musical training and mnemonic modality $F(3, 288) = 189.67, p < .001, \eta^2_p = .664$. Therefore, there is a main effect of trials on word recall. Additionally, strength of the relationship between trials, as assessed by the partial eta square value, accounted for 6.6 % of variance in word recall after controlling for musicianship and mnemonic modality. This finding means that the mean word recall scores were significantly different across trials. As indicated in Table 4, the mean total recall scores significantly increased from Trial 1 to Trial 2 to Trial 3, and significantly decreased in the Final Recall. The results also show that the
recall scores in the later trials (Trials 3 and Final Recall) were significantly greater than the scores in the earlier trials (Trials 1 and 2). The mean total score among all participants was 8.09 in Trial 1, 12.89 in Trial 2, 17.91 in Trial 3, and 15.83 in the Final Recall.

The highest average scores among all participants were observed in the third trial, indicating that repetition can significantly enhance the ability to learn new verbal information over time. Furthermore, this finding indicates that musical rehearsal is just as effective as spoken rehearsal when learning unconnected verbal information. The scores in the Final Recall trial, which was administered immediately following a 10-minute distraction task, also maintained significantly greater values than the average scores in Trials 1 and 2, indicating that musical or spoken rehearsal can also aide in the short-term retention of verbal information. The mean total scores between trials are depicted in the form of a bar graph in Figure 9.

![Figure 9](image-url)

*Figure 9. Mean Total Word Recall Scores Across Trials.*
A paired sample $t$-test was also conducted to show the significant differences between each trial. The results of the pairwise comparisons are provided in Table 8. The paired sample $t$-test reveals the significant differences in mean total word recall scores between each trial.

Table 8

*Pairwise Comparisons Between Trials*

<table>
<thead>
<tr>
<th>Source</th>
<th>Mean Diff</th>
<th>SE</th>
<th>$t$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trials 1 and 2</td>
<td>-4.80</td>
<td>.344</td>
<td>-13.951</td>
<td>.001</td>
</tr>
<tr>
<td>Trials 1 and 3</td>
<td>-9.82</td>
<td>.502</td>
<td>-19.546</td>
<td>.001</td>
</tr>
<tr>
<td>Trials 1 and Final</td>
<td>-7.74</td>
<td>.538</td>
<td>-14.932</td>
<td>.001</td>
</tr>
<tr>
<td>Trials 2 and 3</td>
<td>-5.02</td>
<td>.442</td>
<td>-11.364</td>
<td>.001</td>
</tr>
<tr>
<td>Trials 2 and Final</td>
<td>-2.94</td>
<td>.448</td>
<td>-6.558</td>
<td>.001</td>
</tr>
<tr>
<td>Trials 3 and Final</td>
<td>2.08</td>
<td>.314</td>
<td>6.620</td>
<td>.001</td>
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</tbody>
</table>
Chapter 5
Discussion

The purpose of this study was to examine the effect of musical mnemonics on verbal recall, the effect of musical training on verbal recall, and the interaction effect of musical mnemonics and musical training on verbal recall. Previous research provides evidence that musical mnemonics are an effective tool used to enhance word recall in healthy populations (Chazin & Neuschatz, 1990; McElhinney & Jannett, 1996; Rainey & Larson, 2002; Purnell-Webb & Speelman, 2008; Wallace, 1994) and clinical populations (Claussen & Thaut, 1997; Gfeller, 1983; Thaut et al., 2008).

Other research also supports the effect of musical training on verbal recall in typical populations (Chan et al., 1998; Franklin et al., 2008; Ho et al., 2003; Jakobson et al., 2008). Although these previous studies were informative, they lacked a focus on the interaction effect of musical training and musical mnemonics on verbal recall. While some of these studies accounted for musical training, they lacked a sufficient sample size to reveal significant findings. Therefore, this study sought to determine the combined effect of musical training and musical mnemonics on verbal recall in young adults.

Participants met one time for 30 minutes, in which word recall was examined throughout four trials. The independent variables included Musicianship (musicians and non-musicians) and Mnemonic modality (music and spoken). The dependent variable was Word Recall, which was measured by the correct number of words recalled in the correct order. Each recall trial was scored with one point for each correct word, and two points for each correct word in the correct order. The total possible score was 28.
In this chapter, the results of the statistical analyses will be discussed in detail, as well as theoretical and practical implications. Additionally, this chapter will discuss the limitations of this study and recommendations for future research.

**Discussion of the Research Questions**

The first research question examined whether musical training had an effect on word recall. Results of the present study indicated that the musicians did not recall significantly more or less words than the non-musicians, controlling for trials and mnemonic modality. Therefore, there was no main effect of musicianship on word recall. However, although insignificant, the descriptive results revealed that the musicians recalled more words than the non-musicians across all four trials.

The non-significant effect of musicianship on word recall is inconsistent with previous research findings (Brandler & Rammsayer, 2003; Chan et al., 1998; Ho et al., 2003; Jakobson et al., 2008). In a study comparing intelligence tests between musicians and non-musicians, Brandler and Rammsayer (2003) found that the musicians’ performances on verbal recall tasks were significantly higher than non-musicians. Chan et al., (1998) found that musicians recalled significantly more words than non-musicians across three recall trials. Additionally, Ho et al., (2003) and Jakobson et al. (2008) found significantly greater word recall performance in adults with musical training background compared to those without musical training.

However, the results of this study show that, although not significant, the musicians achieved greater recall scores than the non-musicians throughout all four trials. One reason for the enhanced performance is that the musicians may have utilized rehearsal mechanisms that non-musicians lack during the learning process (Franklin et
Another reason may be that the musicians may have encoded verbal information more efficiently than non-musicians (Jakobson et al., 2008). Several neuroanatomical findings may also explain the musicians’ greater recall scores. First, researchers have observed overlapping activations in brain areas involved during verbal memory tasks to be active during musical memory tasks in musicians only (Koelsch et al., 2009). Finally, researchers found greater activations in areas that are heavily involved in language processes, such as the left planum temporale, of musicians compared to non-musicians (Ohnishi et al., 2001; Schlaug et al., 1995). Therefore, musical training may have produced superior development in brain regions associated with language processing in musicians compared to non-musicians, thus resulting greater word recall scores.

The second research question examined the effect of musical mnemonics on word recall. Results of the present study indicated that there were no statistical differences in word recall scores between the Musical mnemonic and Spoken rehearsal conditions, controlling for trials and musicianship. Therefore, a main effect for Mnemonic modality on word recall was not observed. Although significant differences between Mnemonic modality conditions were not observed, the descriptive results showed that all participants achieved higher recall scores in Trials 3 and 4 in the Musical mnemonic condition than in the Spoken condition.

This finding agrees with previous research in which individuals recalled significantly greater verbal information following a musical rehearsal than spoken rehearsal (Chazin & Neuschatz, 1990; McElhinney & Janet, 1996; Purnell-Webb & Speelman, 2008; Rainey & Larson, 2002; Wallace, 1994). In a study comparing the effect
of a musical mnemonic on verbal recall, Chazin and Neuschatz (1990) found that the participants achieved significantly greater recall scores following the rehearsal of verbal information that was sung to a familiar melody. Wallace (1994) also found that familiar music facilitates the recall of verbal information. Music also provides structural organization and repetition in phrasing which facilitates the learning of verbal information. Additionally, musical elements, such as melody and rhythm provide tonal and temporal structure that enables the ability to chunk information into meaningful units (McElhinney & Janet, 1996; Purnell-Webb & Speelman, 2008; Wallace, 1994). Finally, the results of this study support the findings of Kamahara (2003), who found similar results when comparing the effect of musical mnemonics on language acquisition in young adults.

The results of this study show that music may have facilitated the ability to learn and retain new verbal information for a short period of time, as evidenced by the greater recall scores in the third and final trial. Although the results were not significant, the music may have provided structural elements, such as melody and rhythm that produced greater recall scores in the Musical mnemonic condition. For example, the simple and predictable ascending and descending melodic lines in the song may have enabled the listeners to chunk the verbal information into smaller, more meaningful units. The simple rhythm may have also enabled the ability to chunk information, in addition to providing retrieval cues during the recall tasks. Additionally, the familiarity of the song may have helped produce greater results because it provided an associative link between the new verbal information and familiar melodic information. Finally, the repetition in the musical rehearsal may have facilitated the ability to learn the word list more efficiently.
than the spoken rehearsal. Therefore, the music may have facilitated greater verbal recall scores in the third and final trials through structural elements that provided melodic phrasing and temporal cues, familiarity, and repetition.

The final question examined whether there was an interaction effect between Musicianship and Mnemonic modality. Results indicated that there was no statistically significant interaction between word recall, musicianship, and mnemonic modality. Therefore, no interaction effect existed between musical training and Mnemonic modality. Although significant differences between musical training and Mnemonic modality were not observed, the descriptive results showed that the musicians in the Musical mnemonic condition achieved the highest scores in all recall trials.

Specifically, the results in the third and final recall trials revealed the greatest differences between groups in the Musical mnemonic condition. In the third trial, the musicians’ mean total score was 19.76, and the non-musicians mean total score was 16.68 in the Musical mnemonic condition. In the final recall, the musicians’ mean total score was 17.52, and the non-musicians’ mean total score was 14.60 in the Musical mnemonic condition.

These findings show that, although statistically insignificant, a musical mnemonic may produce enhanced verbal recall for musicians. Several researchers explain that musicians might utilize certain rehearsal mechanisms that naturally enhance verbal learning when information is paired with a musical accompaniment (Franklin et al., 2008). Other researchers suggest that musical training may enhance cognitive activity in certain brain areas, such as the left PT, that are associated with both verbal learning and musical processing (Ohnishi et al., 2001; Schlaug et al., 1995).
Last, the participants’ mean total recall scores most likely decreased between the third and final trials because of the distraction task, in which they worked on a math problem for 10-minutes. Although a decrease was observed, the participants’ mean total scores in the final trial were greater than scores in Trials 1 and 2. The participants were able to maintain the verbal information despite a 10-minute distraction task, indicating the efficacy of rehearsal on encoding and maintenance of new information.

**Discussion of Additional Findings**

Results of this study also showed that participants’ mean total scores in both the musical mnemonic and spoken rehearsal conditions significantly differed between each trial. In other words, the mean total scores were significantly greater or lesser between Trial 1, Trial 2, Trial 3, and the Final Recall. The results showed that the average scores significantly increased from Trial 1 to Trial 2 and Trial 2 to Trial 3, indicating the critical role of repetition during verbal learning. Additionally, the results showed a significant decrease in the average scores from Trial 3 to the Final Recall. However, the Final Recall average score remained significantly greater than the mean total scores from Trial 1 and Trial 2. This finding suggests that learning may have occurred regardless of the mnemonic modality or musical training, and that musical rehearsal is just as effective as spoken rehearsal for short-term retention of verbal information. This finding is consistent with Kamahara (2003), who found similar results when comparing the effect of musical mnemonics on language acquisition in young adults.

Theorists such as Baddeley (2012) and Vallar (2006) have discussed the role of the subvocal articulatory rehearsal system, which helps maintain verbal information in
the phonological store for further encoding and transfer into memory. Repetition of verbal material, whether rehearsed overtly or covertly, enhances the ability to store and retrieve verbal information from short-term and long-term memory stores. The participants in this study were given the task to listen to the sung or spoken rehearsal, and covertly rehearse the verbal material. The results showed an increase in verbal recall throughout the first three trials in both rehearsal conditions. Therefore, this finding shows the significance of repetition on verbal learning, and that musical rehearsal is just as effective as spoken rehearsal.

**Participant Feedback**

The participants’ narrative comments in the questionnaires provided insight regarding the effectiveness of the spoken and musical mnemonic rehearsals (see Appendix G). Of the 50 participants in the Musical mnemonic condition, five non-musicians and six musicians reported that the musical mnemonic did not help them learn the word list. The participants explained that they were distracted by the original lyrics of the melody, thought the melody was out of tune, or found other strategies to be more effective. The participants also explained that they needed more repetition, found the visual aide more helpful, or were unfamiliar with the melody. Some participants also blocked out the music altogether, and memorized the words from the provided list.

The other participants in the Musical mnemonic condition, 12 non-musicians and 20 musicians, reported that the musical mnemonic helped them learn the word list because the words matched the rhythm of the song, the singing was easy to follow, or the melody was familiar. The participants also explained that the phrases were repeated and the rhythm and melody provided cues for certain words. Two musicians said the phrasing
of the melody chunked the information together which supports previous findings in musical mnemonic literature (McElhinney & Janet, 1996). Four other musicians said the music provided an association between the melody and the words which facilitated recall of the word list. These observations are consistent with the findings of previous researchers who describe music as a structural framework that provides an associative link between melody and verbal information (Wallace, 1994). One participant also wrote, “The musical mnemonic was helpful because it was repetitive. The melody was stuck in my head, which made it easier to recall the words.” This statement is consistent with research that discusses the significant role of melodic repetition on verbal recall (Purnell-Webb & Speelman, 2008; Wallace, 1994).

The narratives also revealed a variety of responses regarding the effect of familiarity with the melody which caused favorable and adverse effects on verbal recall. First, participants who were familiar with the melody said the musical mnemonic was helpful because “the music provided an associative link to the text.” Others found the familiar melody to not be helpful because they were too distracted by the original song lyrics as written by The Beatles. One participant stated, “I was mixing up the word list with the actual lyrics of the song.”

Second, some participants who were unfamiliar with the melody found the musical mnemonic helpful. One participant wrote, “The musical mnemonic was helpful because I used the rhythm to remember the words through thumping my feet to the beat.” Others who were unfamiliar with the melody also found the musical mnemonic to not be helpful. One participant reported, “It was difficult to remember the words because I had memorized the melody.” This statement confirms the negative effect of pairing new
verbal information with a novel melody, in which an overwhelming amount of information may produce cognitive overload. Overall, this observation supports the effect of familiar music on verbal recall which is consistent with other musical mnemonic research (Chazin & Neuschatz, 1990; Purnell-Webb & Speelman, 2008; Rainey & Larsen, 2002; Wallace, 1994).

The melodic and rhythmic structure of the music also helped the participants to chunk the words into meaningful groups, and provided a cue for retrieval of words. One participant commented on the preservation of the prosody of the words in the song, “The words matched the rhythm of the song.” Another participant explained that the musical mnemonic provided an associative link between the familiar melody and new verbal information, “I associated the pitches of the song with the words.” A third participant also reported that the structural elements of the song facilitated her ability to group the information into smaller, more meaningful units, “The song was broken into sections, so I was able to break down the word list into smaller chunks.” These responses help support previous research that describes the effect of melodic and rhythmic structure of music on word recall (Dowling, 1973; McElhinney & Janet, 1996; Wallace, 1994). Last, several factors that challenged the participants to recall the words were the order, the lack of lyrical meaning, limited repetition, and not hearing the recording between the distraction task and final recall.

In the Spoken condition, half of the participants, 10 musicians and 7 non-musicians, found the spoken rehearsal to not be helpful. Several participants said the recording was distracting and found it easier to block out the recording altogether. Therefore, some participants preferred to read the word list without the auditory
presentation. Other participants also stated that the recording was too fast or too boring.

The other 33 participants found the spoken rehearsal helpful because it provided repetition and the correct pronunciation of each word. Several challenges the participants reported were recalling the words in order, distinguishing words that began with the same letter, and not hearing the recording between the distraction task and final recall. Other reported challenges included unfamiliarity with the words, too many words, and a limited time to learn the words.

Forty-three participants in the Spoken condition and 38 participants in the Musical mnemonic condition said the word list was a helpful visual aide for several reasons. Most participants considered themselves to be visual learners. Other participants said the word list enabled them to visually match the words with the presentation, thus providing a good reinforcement when listening to the recording. Participants also reported that the word list was helpful because it allowed them to see and understand the words more clearly, to visualize the words on the paper during recall, to associate words with the order number, and to spell the words correctly. The participants reported to have had the most difficulty recalling the words in the middle and end of the list.

**Limitations of the Study**

A number of limitations exist for this study. First, the sample included individuals with a wide range of differences in their history of musical training. Although 81% of the participants fully met the criteria as a musician or non-musician, the researcher made several exceptions due to a limited response in participant volunteers and recruitment opportunities. Several non-musicians reported to have had musical experiences other than music lessons or performance groups. For example, one participant reported to have sung
for 18 years, but never began musical training at a particular age, and never took formal or self-taught music lessons. Therefore, this participant qualified as a non-musician for this study even though she reportedly had been singing for 18 years.

Furthermore, several musicians did not entirely meet the participant criteria in terms of the age they began receiving music lessons and number of playing hours per week. For example, one participant began to learn his instrument at the age of 11-years-old, and another participant reported to perform her instrument for an average of one to five hours per week. Although several musicians did not fully meet the criteria, the researcher allowed participation if three out of the four requirements were met. Therefore, the lack of consistency in musical training may have influenced the results. The inability to find participants that fully met the criteria for musical training may have prevented the researcher’s ability to find statistically significant differences between the musicians and non-musicians. Future researchers should design participant criteria that require individuals to meet more distinct requirements in order to compare results between two contrasting groups.

A second limitation in this study was the sample size. Although 100 participants appear to be a sufficient size, it may be more effective to use a larger sample of participants. Most researchers that investigated the effect of musical mnemonics on word recall, or the effect of musical training on word recall, reported significant findings in sample sizes that included up to 40 participants. Those previous researchers also enabled individuals who met a certain level of musical ability to participate, thus avoiding the chance for similarities between musicians and non-musicians to exist. Additionally, this researcher conducted a power analysis prior to the study which suggested that 100
participants would produce significant results. Although differences emerged in mean scores between groups, the results in this study were not significant. One reason may be due to lack of criteria distinction between musicians and non-musicians. The inclusion of two groups who lack significant differences may require a larger sample size to produce statistically significant results. Therefore, the sample size may have been too small to reach statistical significance.

Third, the researcher did not provide the participants the opportunity to covertly rehearse, or the ability to sing or speak out loud, the material along with the recording. Several participants reported that they would have performed better if they were given the opportunity to recite out loud along with the recording or during the recall trials. Although the researcher did not advise against the technique, the opportunity was not offered or encouraged. The ability to recite the material out loud along with the recording may produce better recall scores because the participants would be more focused on the learning task, thus enhancing the ability to attend and encode more efficiently. Additionally, according to the phonological short-term store (STS) model described by Vallar (2006), the overt rehearsal of verbal information re-enters through the ears back into the store via auditory feedback. Therefore, the auditory feedback produced by the participants may facilitate the ability to learn the word list more effectively rather than through internal rehearsal.

Fourth, numerous environmental distractions were present during the sessions, which may have interfered with the participants’ performance during the learning and recall trials. The researcher made every effort to remove any distractions that were present, however several disturbances that occurred were beyond control. The study
rooms in the libraries were not sound-proof; therefore, it was easy to overhear other groups in study rooms that were nearby or next to each other. Furthermore, construction was taking place directly outside the rooms that were reserved for quiet space, so that noises from drills and hammering was heard at random times. Another distraction may have been the walls of the study room which were large windows; making it easy to see any activity that may have taken place outside of the study room during the sessions. These distractions may have interfered with the participants’ ability to fully focus and engage in the tasks at hand, thus detrimentally affecting the results of this study.

A fifth limitation may have been the design and choice of song used in the musical mnemonic. Many participants were distracted by the original lyrics of the song “Yesterday,” which prevented them from learning the new verbal information. Additionally, the rhythmic structure of “Yesterday” may have not provided sufficient phrasing and temporal cues conducive for efficient learning and retrieval of verbal information. The slow tempo of the song may have inhibited the presence of a strong, accentual beat, which may have prevented the listener’s ability to group the melodic and rhythmic components of information into meaningful units. Perhaps a more effective musical mnemonic comprises a familiar song that is upbeat and consists of a clear and steady accented beat. Therefore, the lack of the temporal structure in the song “Yesterday” may have suppressed the ability to learn the word list more efficiently.

Another limitation in this study may have been the learning material. The word list may have been a weak source of content to measure short-term word recall because it contained 14 words that were unfamiliar to the participants. Therefore, the word list may have distracted the participants from learning from the musical mnemonic because the
content may have been too novel or too random to process along with the musical information. The word list may have also been difficult to learn because it consisted of unconnected text, or verbal information that lacks any type of semantic or lyrical structure. Researchers have found similar results regarding the short-term recall of unconnected text in which significant differences between the sung and spoken rehearsal of verbal information were not observed (Rainey & Larson, 2002). However, researchers have found that musical mnemonics can significantly improve the short-term recall of lyrical information (Chazin & Neuschatz, 1990; Purnell-Webb & Speelman, 2008; Wallace, 1994). Therefore, a musical mnemonic may be more effective for the immediate learning and recall lyrical of lyrical information, and not unconnected text.

The last limitation to this study was that the participants were incoming freshmen who were meeting with the researcher during the first two weeks of classes. Therefore, the participants may have been overwhelmed with adapting to their new environment, attending classes and accumulating coursework, and learning to begin an independent lifestyle. The participants may have been stressed with personal and academic issues that may have interfered with the ability to fully focus on the learning and recall tasks.

**Theoretical Implications**

This study provides evidence of the effect of music on verbal memory in three ways. First, this study provides additional evidence that musical mnemonics can facilitate verbal learning. Second, this study provides additional findings that support the effect of musical training on word recall as evidenced by greater mean verbal recall scores in musicians than non-musicians. Third, this study introduces a new area of interest to literature in which the combination of music therapy and music education is examined to
determine outcomes in cognitive processes, such as verbal short-term memory. Additionally, this study shows the significance of rehearsal (spoken or sung) on verbal learning and short-term recall of unconnected text.

Future research needs to be done to determine if a positive relationship between musical mnemonics and musical training exists in terms of enhanced verbal learning and short-term recall of unconnected text. This study provides an introduction to the combined use of musical mnemonics and training on improved cognitive processes in healthy young adults, and could be an effective tool for clinical populations. Therefore, future research should be done to investigate the combined effect of musical training and musical therapeutic techniques on cognitive domains (e.g., attention, memory, and executive functions) and behavioral domains (e.g., impulse control) in typical and clinical populations.

**Practical Implications**

This study provides evidence of improved verbal memory in individuals with and without musical training through repetition and rehearsal. Regardless of rehearsal modality, individuals can learn more information with repetition. Individuals at a college level tend to go through rigorous coursework in which memorizing facts, names, dates, terms, equations, and definitions is a regular task. Therefore, the results of this study show that in order to learn and retain information, an individual must rehearse that information. Rehearsal of information can apply to individuals of all ages and grades because memorizing information is often a daily task.

The results of this study also provide evidence that music can facilitate verbal recall in young adults. The findings show that musical rehearsal is just as effective as
verbal rehearsal in both musicians and non-musicians. A musical mnemonic can be used to help rehearse information for several reasons: 1) melodic and rhythmic phrasing helps to chunk information into groups of information, 2) musical information provides structure that serves as a cue for retrieval, and 3) music provides a framework that serves as a link between new verbal information and a familiar melody (Wallace, 1994).

The use of a musical mnemonic should be further investigated in clinical populations in which individuals with cognitive deficits (e.g., Attention-deficit hyperactivity disorder, learning disabilities, traumatic brain injury, intellectual disabilities, multiple sclerosis, and Alzheimer’s disease) would benefit. Musical mnemonics that utilize familiar music can improve verbal learning in individuals with learning disabilities because it provides melodic and rhythmic elements that facilitate the ability to organize information into meaningful units (Claussen & Thaut, 1997; Gfeller, 1983). Musical mnemonics can also facilitate verbal learning in adults with multiple sclerosis because the temporal structure can help improve the ability to chunk information more effectively (Thaut et al., 2005). Finally, Simmons-Stern et al., (2010) found that adults with Alzheimer’s disease may encode verbal information that is sung more efficiently than healthy adults. Therefore, research shows that musical mnemonics can significantly improve verbal memory in individuals with memory deficits.

Previous research also shows that musical training can significantly enhance verbal learning in healthy individuals (Chan et al., 1998; Franklin et al., 2008; Jakobson et al., 2008). Therefore, clinical populations may benefit from the combination of musical
mnemonics training and musical training on the ability to learn information that is necessary for everyday functions, including academic (e.g., vocabulary and mathematic equations) and procedural information (e.g., social and emotional behaviors).

**Recommendations for Future Research**

Future research should continue to explore the effects of musical training and musical mnemonics on verbal memory. First, the results of this study showed a high variance level between recall scores as evidenced by large standard deviations in each trial. Therefore, future studies should include larger sample sizes to decrease the level of variance between groups, thus increasing the chance of reaching statistically significant results. Furthermore, although the results of this study did not reach significance, the overall performance of the musicians in the musical mnemonic condition was greater than the other groups. Therefore, a larger sample size might also increase the likelihood for the musicians in the musical mnemonic condition to achieve statistically significant results, thus showing stronger evidence of the combined effect of musical training and musical mnemonics on verbal memory.

Future studies should also compare different types of musicians, such as vocalists and instrumentalists. Musicians utilize rehearsal strategies for music which might influence the strategies used during the rehearsal of other information. However, vocalists are more often required to learn and memorize lyrics to a song than instrumentalists who are required to learn finger combinations and motor techniques to perform music. Perhaps vocalists utilize more efficient rehearsal skills when learning verbal information that is sung to a melody. Future research might show the effects of different types of musical training, such as vocal and instrumental instruction, on verbal
memory and other cognitive functions. The findings might help guide music therapists to determine which appropriate instruments and activities to use in order to address certain cognitive deficits. For example, if researchers find that vocal instruction produces significantly better recall of verbal information than instrumental instruction, then voice lessons and choir participation might be an appropriate form of musical training used to facilitate and improve verbal learning.

Another recommendation for future research is to focus participant criteria specifically on musical training and expertise. For example, several music majors in this study lacked the amount of musical training that was needed to fit the criteria as a musician. Therefore, participant selection should be based more on musical training and musical experience than college major. Additionally, future studies should take into consideration the number of years individuals received music education at the primary education level. Most elementary students receive music in the classroom until the age of nine-years-old, in which children sing in the choir, learn to read music, and learn to play the recorder. Although music education at the elementary level is not considered formal musical training, many students learn and experience music at a basic level. Therefore, it is important to define participants with more specific criteria, in which exceptions are not possible.

Additionally, researchers should collect information regarding grade point average (GPA) in order to determine whether a relationship between aptitude and memory exists. This researcher neglected to collect information regarding GPA, which may have hindered an opportunity to determine whether a difference in aptitude between the musicians and non-musicians were present. Therefore, the researcher was not able to
report whether a range in levels of aptitude in the participants existed, and whether the participants with a higher aptitude scored better verbal recall scores than participants with a lower aptitude.

Studies should also explore the long-term effect of musical mnemonics on recall of unconnected text in musicians and non-musicians. Researchers have found the significant effect of musical mnemonics on long-term memory in young adults (Rainey & Larson, 2002). However, the long-term effect of musical mnemonics and musical training has yet to be addressed. This study investigated the short-term effect of musical mnemonics and musical training on word recall. Therefore, future research might incorporate a post-test in which participants try to recall the words one week later, thus showing the long-term effect of a musical mnemonic on verbal recall of unconnected text in musicians. A researcher might be able to determine if musicians are able to retain that information longer than non-musicians. A researcher might also be able to determine if musical rehearsal is more effective than spoken rehearsal for LTM recall tasks.

Last, researchers should continue to examine the effect of musical mnemonics on verbal memory in populations with memory deficits, such Attention-Deficit Hyperactivity Disorder, Learning Disabilities, and Traumatic Brain Injury (TBI). Musical training alone might also produce significant improvements in memory in clinical populations. Children with disabilities, such Attention-Deficit Hyperactivity Disorder, and Autism Spectrum Disorder (ASD) who receive formal music lessons or perform in the school band might experience cognitive benefits. Therefore, researchers should begin to examine the effect of musical training, or simply the musical experience within the music classroom, on verbal memory in clinical populations. The combined effect of
musical training and musical mnemonics should also be examined in childhood and young adult clinical populations. Researchers have shown significant effects of musical mnemonics on verbal recall in children with memory deficits (Claussen & Thaut, 1997; and Gfeller, 1997). Therefore, the combined effect musical training and musical mnemonics might produce optimal results in clinical populations.

**Summary and Conclusions**

The purpose of this study was to examine the verbal recall in musicians and non-musicians following a musical or spoken rehearsal. A three-way interaction analysis of the data showed no significant differences between trials, musicianship, and mnemonic modality. However, significant results were evident between trials, controlling for musicianship and mnemonic modality. These findings mean that musical rehearsal of verbal information is just as effective as spoken rehearsal in musicians and non-musicians, and that repetition and rehearsal are key components to learning and memorizing information. The participants’ recall improved across the first three trials, and decreased in the final recall, which followed a distraction task. The participants achieved the highest scores in the third recall trial, which indicates a significant relationship between repetition and verbal memory. Furthermore, although not statistically significant, the musicians in the Musical mnemonic condition scored the highest mean total scores in all four trials. Therefore, these findings support the effect of music as a learning tool for several reasons.

Musical structure helps chunk information into organized, repetitive patterns or groups, thus enhancing the ability to encode, store, and recall information. Musical elements, such as melody and rhythm, provide structural cues for retrieval during recall.
Familiar music also facilitates learning because it provides an associative link between verbal and musical information. Finally, the participants reported to have enjoyed the musical rehearsal. Some participants said they would use a musical mnemonic to learn new information because “it helps with memory and is fun.” Therefore, a musical mnemonic can be a motivating and effective tool for individuals with and without musical training to learn connected (i.e., lyrics) and unconnected text (i.e., word lists). Musical mnemonics can also be used for basic day to day memorization, such as directions or number combinations, or as a study tool for academic information.
References


Appendix A: Recruitment Flyer

University of Miami

The Combined Effect of Musical Training and Musical mnemonics on Verbal Recall

Volunteers Wanted for Research Study

You are invited to participate in a research study. The study is designed to examine the combined effect of musical training and musical mnemonics on verbal recall in college students.

In order to participate in this study, all participants must be a FRESHMAN currently enrolled at the University of Miami. Participants must be able to speak English fluently. Participants with learning disabilities will not be included in this study. Participants need to meet with the researcher only one time for 30 minutes on the University of Miami campus in Coral Gables.

*Must be at least 18 years old to participate*

Looking for participants with musical training who:

• Began learning an instrument before the age of nine
• Currently take formal instrumental or vocal lessons
• Practice or play their instrument at least 10 hours a week
• Major in music and enrolled in at least nine credits of music classes

Looking for participants without musical training who:

• Received less than one year of private music lessons
• Received less than two years of self-taught musical instruction
• Do not major in music and enrolled in less than nine credits of music classes
• Do not have musical skills such as reading or performing on a musical instrument

*Psychology freshman students will receive credit for their participation.

Research will be conducted at the University of Miami. To learn more about this research, please contact Allison Pindale, student investigator, 609-314-5667, or email apindale@gmail.com

This research is conducted under the direction of:
Teresa Lesiuk, Ph. D., MT-BC
University of Miami Frost School of Music
P. O Box 248165
Coral Gables, FL 33124
(305) 284-3650
Appendix B: Demographic Questionnaires

**Questionnaire Part I**
Please fill out the questionnaire to your fullest potential. The information you provide will be used strictly for this study. Anything you share will be kept confidential.

**Age:** ______

**Degree Major/Concentration:** __________________________

**Gender (circle):** Male / Female

**English speaker (circle):** Yes / No

**Are you a Freshman? (circle):** Yes / No

1. What, if any, instrument(s) do you play or sing? __________________________

2. How many years have you played or sang? _________________________________

3. If applicable, how many years have you taken formal music lessons? _____________

4. If applicable, how many years have you received self-taught music lessons?

5. If applicable, please circle the average number of hours you spend playing and/or practicing your instrument(s) **weekly**? (includes ensemble rehearsals)

   1-5  6-10  10-15  16+

6. At what age did you begin learning to play music? ______________

7. Are you currently taking private lessons at the University of Miami?  YES / NO

8. Are you currently enrolled in 9 or more credit music hours?  YES / NO

9. What is the daily average number of hours you listen to music

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(Music) Questionnaire Part II

Please fill out the questionnaire to your fullest potential. The information you provide will be used strictly for this study. Anything you share will be kept confidential.

1. What are some learning strategies you use to memorize information? (i.e., flash cards/study groups/pictures/mnemonic devices)

2. What learning strategies do you find to be the most effective?

3. What type of information do you use these strategies to learn? (i.e., phone numbers, directions, study materials, words lists, names, etc.)

4. How familiar are you with musical mnemonics? (circle one)
   
   1. very unfamiliar
   2. heard of it, but am unfamiliar
   3. heard of it, and slightly familiar
   4. very familiar

5. Have you ever used a musical mnemonic to learn or memorize information? (circle)

   YES / NO / I DON’T KNOW
6. If so, what type of information do you use musical mnemonics to memorize? (i.e., phone numbers, directions, word lists, names, etc.)

7. If not, would you consider using musical mnemonics in the future? Why or why not?

8. Do you think the musical mnemonic helped you memorize the word list? Why or why not?

9. What did you find challenging about recalling the word list at the end of the session?

10. Do you think you recalled a reasonable number of words? Why or why not?

11. How familiar are you with the melody? Please write the name of the song and/or the artist.
(Spoken) Questionnaire Part II

Please fill out the questionnaire to your fullest potential. The information you provide will be used strictly for this study. Anything you share will be kept confidential.

1. What are some study strategies you use to memorize information? (i.e., flash cards/study groups/pictures/mnemonic devices)

2. What strategies do you find to be the most effective? Why?

3. What type of information do you use these learning strategies for? (i.e., phone numbers, directions, study materials, word lists, names, etc.)

4. Have you ever used a mnemonic device to learn or memorize information? (acronyms, melodies, etc.)

5. If so, what type of information do you use mnemonic devices to learn or memorize? (i.e., phone numbers, directions, study materials, word lists, names, etc.)
6. Did you find the repetitive verbal rehearsal helpful in memorizing the list of words? Why or why not?

7. What did you find challenging about recalling the word list at the end of the session?

8. Do you think you recalled a reasonable number of words? Why or why not?

9. Do you like to listen to music when you study? Why or why not?

10. How familiar are you with musical mnemonics? (circle one)

   1  2  3  4
very unfamiliar heard of it, but heard of it, and very familiar
am unfamiliar slightly familiar
Appendix C: Recall Forms

Word List Recall 1

1. ________________________________
2. ________________________________
3. ________________________________
4. ________________________________
5. ________________________________
6. ________________________________
7. ________________________________
8. ________________________________
9. ________________________________
10. ________________________________
11. ________________________________
12. ________________________________
13. ________________________________
14. ________________________________
Word List Recall 2

1. ________________________________
2. ________________________________
3. ________________________________
4. ________________________________
5. ________________________________
6. ________________________________
7. ________________________________
8. ________________________________
9. ________________________________
10. ________________________________
11. ________________________________
12. ________________________________
13. ________________________________
14. ________________________________
Word List Recall 3

1. ________________________________
2. ________________________________
3. ________________________________
4. ________________________________
5. ________________________________
6. ________________________________
7. ________________________________
8. ________________________________
9. ________________________________
10. ________________________________
11. ________________________________
12. ________________________________
13. ________________________________
14. ________________________________
Word List Final Recall

1. ___________________________________________________________________
2. ___________________________________________________________________
3. ___________________________________________________________________
4. ___________________________________________________________________
5. ___________________________________________________________________
6. ___________________________________________________________________
7. ___________________________________________________________________
8. ___________________________________________________________________
9. ___________________________________________________________________
10. ___________________________________________________________________
11. ___________________________________________________________________
12. ___________________________________________________________________
13. ___________________________________________________________________
14. ___________________________________________________________________
Appendix D: Informed Consent

University of Miami
CONSENT TO PARTICIPATE IN A RESEARCH STUDY
The Combined Effect of Musical Training and Musical mnemonics on Verbal Recall

The following information describes the research study in which you are being asked to participate. Please read the information carefully. At the end, you will be asked to sign if you agree to participate.

ELIGIBILITY:
All participants in this study must be at least 18 years old.

PURPOSE OF STUDY:
You are being asked to participate in a research study, entitled “The Combined Effect of Musical Training and Musical mnemonics on Verbal Recall.” The purpose of this study is to find the effect of a musical mnemonic on verbal recall in college students who have and have not received musical training.

PROCEDURES:
You will be asked to fill out one questionnaire in regard to your musical history. Then you will be randomly assigned to one of two conditions, Musical mnemonic or Spoken condition.

In the Musical mnemonic condition, you will be asked to learn and recall a list of words after undergoing a simple rehearsal technique based on a musical mnemonic. A musical mnemonic is the application of information to a familiar melody, such as setting the alphabet to the melody of “Twinkle Twinkle.” During the session, you will go through 4 Trials.

In Trial 1 you will:
   a. Listen and read along with the presentation
   b. Recall and write as many words from the list as possible
In Trial 2 you will:
   c. Listen and read along with the presentation
   d. Recall and write as many words from the list as possible
In Trial 3 you will:
   e. Listen and read along with the presentation
In Trial 4 you will:
   f. Listen and read along with the presentation
   g. Recall and write as many words from the list as possible

Following this protocol, you will be asked to perform a simple mental arithmetic task for 10 minutes. Then, you will be asked to recall and write as many words from the same word list as possible.
In the Spoken condition, you will be asked to learn and recall a list of words after undergoing a simple verbal rehearsal technique. You will go through 5 trials that will be presented in the similar format as the Musical mnemonic condition. However, music will not be included. The information will be presented to you verbally.

RISKS AND/OR DISCOMFORTS:
There are no risks or discomforts in this study.

BENEFITS:
No benefits can be promised to you from your participation in this study. However, you may learn a new rehearsal technique that will help improve memory.

CONFIDENTIALITY:
The researcher will consider all information throughout the study confidential. The investigators and their assistants will consider your records confidential to the extent permitted by law. The U.S Department of Health and Human Services (DHHS) may request to review and obtain copies of your records. Your records may also be reviewed for audit purposes by authorized University, or other agents, who will be bound by the same provisions of confidentiality. Records will be stored on a secure and locked computer and the principal investigator and student investigator will have access to individual data.

COMPENSATION:
There is no compensation as a result of participating in this study. Students in the psychology department will receive 1 credit per half hour for their participation.

RIGHT TO DECLINE OR WITHDRAW:
Your participation in this study is voluntary. You are free to refuse to participate in the study or withdraw your consent at any time during the study. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest for you.

CONTACT INFORMATION:
Teresa L. Lesiuk Ph. D., MT-BC (305-284-3650) will gladly answer any questions you may have concerning the purpose, procedures, and outcome of this project. If you have any questions concerning the research study, please contact Allison Pindale, Master’s Degree Candidate (609-314-5667) or apindale@gmail.com. If you have questions about your rights as a research subject you may contact the Human Subjects Research Office at the University of Miami, at (305) 243-3195.

PARTICIPANT AGREEMENT: I have read the information in this consent form and agree to participate in this study. I have had the chance to ask any questions I
have about this study, and they have been answered for me. I am entitled to a copy of this form after it has been read and signed.

<table>
<thead>
<tr>
<th>Signature of Participant</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signature of person obtaining consent</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix E: Distraction Task

Count down by 7 from 1,500.

(Do not show your work. Do the math in your head, please.)

1,500....1,493....etc.
Appendix F: Musical mnemonic

\[
\begin{align*}
\text{Ab-dic-ate, maw-kish, in-cre-ment, os-ten-sible, circum-spect, in-trep-id,} \\
\text{whim-sical, capit-u-late, ne-far-i-ous. succ-int, flor-id, in-cess-ant hap-less, emi-nent} \\
\text{Suc-cint, flor-id, in-cess-ant, hap-less, emi-ne-nt. Ab-di-cate,} \\
\text{maw-kish, in-cre-ment, os-ten-sible, circum-spect, in-trep-id,} \\
\text{whim-sical, capit-u-late, ne-far-i-ous.}
\end{align*}
\]
Appendix G: Word List

**Word List**

1. Abdicate
2. Mawkish
3. Increment
4. Ostensible
5. Circumspect
6. Intrepid
7. Whimsical
8. Capitulate
9. Nefarious
10. Succinct
11. Florid
12. Incessant
13. Hapless
14. Eminent
Appendix H Participants’ Narrative Responses

Musicians – Musical mnemonic condition

1. What are some learning strategies you use to memorize information?
   Flash cards, repetition, mnemonic devices, writing information out, speaking out loud, acronyms, rhythm, listening to classical music, study groups, rhymes, pictures, singing, discussions, language, definitions, procedures, and movements.

2. What type of information do you use these learning strategies for?
   Word lists, phone numbers, names, study material, musical lyrics, math, science, history, dates, directions, songs, scales, and exercises.

3. How familiar with musical mnemonics are you?
   Very unfamiliar
   Heard of it, but am unfamiliar (3)
   Heard of it, and slightly familiar (14)
   Very familiar (6)

4. Would you consider using, or have you used, a musical mnemonic? Why or why not?

<table>
<thead>
<tr>
<th>Yes (19)</th>
<th>No (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helps remember information and is fun</td>
<td>Other strategies work better for me.</td>
</tr>
<tr>
<td>Helps recall if the melody is memorable</td>
<td>Not creative enough.</td>
</tr>
<tr>
<td>For Spanish vocabulary – learned the words faster than usual strategies.</td>
<td>Get stuck in my head and become annoying.</td>
</tr>
<tr>
<td>For strings of numbers or words.</td>
<td>Too time consuming.</td>
</tr>
<tr>
<td>For math equations, history, and music intervals.</td>
<td></td>
</tr>
<tr>
<td>I love music.</td>
<td></td>
</tr>
</tbody>
</table>

5. Did the musical mnemonic help you memorize the word list? Why or why not?

<table>
<thead>
<tr>
<th>Yes (20)</th>
<th>No (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distracted by actual lyrics of the song.</td>
<td>It was out of tune.</td>
</tr>
<tr>
<td>It</td>
<td></td>
</tr>
</tbody>
</table>

130
6. Did the word list provide a helpful visual aide? Why or why not?

<table>
<thead>
<tr>
<th>Yes (22)</th>
<th>No (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Helped remember the order of words because I matched the words with the corresponding number.</td>
<td></td>
</tr>
<tr>
<td>Visual learner.</td>
<td>Music was more helpful</td>
</tr>
<tr>
<td>Provided a good reinforcement during the listening.</td>
<td></td>
</tr>
<tr>
<td>Able to see and compare how each syllable was sung.</td>
<td></td>
</tr>
<tr>
<td>Noticed patterns in the words – such as beginning letters.</td>
<td></td>
</tr>
<tr>
<td>Words were unfamiliar.</td>
<td></td>
</tr>
<tr>
<td>Able to visualize the words.</td>
<td></td>
</tr>
<tr>
<td>Were like lyrics.</td>
<td></td>
</tr>
</tbody>
</table>

7. Did you sing along to the musical mnemonic during the presentation or during the recall?
   - Yes, during the presentation and during the recall (19)
   - Yes, only during the recall (4)
   - No, during neither (2)

8. What did you find challenging during the recall trials?
   - Remembering the order and all the words
   - Confused by actual lyrics
   - Lack of lyrical meaning made it hard to piece information together
   - Remembering the first word of a phrase, which inhibited me from recalling the words in the rest of the phrase
   - Recalling the middle part of list
   - The words were difficult and unfamiliar
Non-musicians – Musical mnemonic condition

1. What are some learning strategies you use to memorize information?
   Flash cards, repetition, mnemonic devices, taking notes, hand gestures, making connections, writing information out, reading out loud, creating stories, visual presentations, pictures, study groups, acronyms, highlighting, sets of numbers, listening to music, power point, reviewing, rhymes, outlines, and reading.

2. What type of information do you use these learning strategies for?
   Word lists, phone numbers, names, study material, addresses, directions, names, SSN, C#, vocabulary, science, and history.

3. How familiar with musical mnemonics are you?
   - Very unfamiliar (9)
   - Heard of it, but am unfamiliar (10)
   - Heard of it, and slightly familiar (5)
   - Very familiar (1)

4. Would you ever consider using a musical mnemonic in the future? Why or why not?

<table>
<thead>
<tr>
<th>Yes (20)</th>
<th>No (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The beat can help make it easier to remember something.</td>
<td>Doesn’t work for me.</td>
</tr>
<tr>
<td>Help with chunking.</td>
<td>I think it would confuse me and would require me to think more.</td>
</tr>
<tr>
<td>The rhythm was helpful.</td>
<td>Too much work.</td>
</tr>
<tr>
<td>Great study tool.</td>
<td></td>
</tr>
<tr>
<td>Seemed to work very well with my recall.</td>
<td></td>
</tr>
<tr>
<td>Phone numbers/ABC’s/Vocabulary/Continents/Directions</td>
<td></td>
</tr>
<tr>
<td>Less tedious learning task when sung to a melody – and is fun.</td>
<td></td>
</tr>
<tr>
<td>Makes material easier to understand and break down.</td>
<td></td>
</tr>
</tbody>
</table>

5. Did the musical mnemonic help you memorize the word list? Why or why not?

<table>
<thead>
<tr>
<th>Yes (13)</th>
<th>No (12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recalled words that were more stressed and sung beautifully.</td>
<td>Focused more on picturing the words in my head.</td>
</tr>
<tr>
<td>The beat of the song was helpful.</td>
<td>Thought about song more than words.</td>
</tr>
<tr>
<td>Melody made it easier to remember the words.</td>
<td>Distracted by the music.</td>
</tr>
<tr>
<td>It was a familiar tune.</td>
<td>Was distracted.</td>
</tr>
<tr>
<td>Made the words stand out more clearly.</td>
<td></td>
</tr>
<tr>
<td>Played it in my head and was able to recall.</td>
<td></td>
</tr>
</tbody>
</table>
Able to sound out the order of words with the song. Singing made it easier to follow along. But would have performed better without the music. Melody helped match words to the song. Helped in the last two recalls.

Just memorized the words on the paper. Just memorized words that were more or less interesting to me. Straight memorization would have been more effective. Would be able to capture the words better with more repetition. Distracted by the actual lyrics. Not used to that method.

6. Did the word list provide a helpful visual aide? Why or why not?

<table>
<thead>
<tr>
<th>Yes (21)</th>
<th>No (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provided the order of words.</td>
<td>Got used to the fact that I had the list in my hands.</td>
</tr>
<tr>
<td>Wasn’t lost when I followed the music.</td>
<td>The word list was random.</td>
</tr>
<tr>
<td>Vocalist was somewhat hard to understand at some points.</td>
<td>Hard to follow with the song.</td>
</tr>
<tr>
<td>Helped me capture the words better.</td>
<td></td>
</tr>
<tr>
<td>Helped me visualize what the words would look like when written Visual learner.</td>
<td></td>
</tr>
<tr>
<td>Able to see words while listening.</td>
<td></td>
</tr>
<tr>
<td>A little – but blanked out sometimes to listen to song Usual learning method.</td>
<td></td>
</tr>
</tbody>
</table>

7. Did you sing along to the musical mnemonic during the presentation or during the recall?

Yes, during the presentation and during the recall (14)
Yes, only during the recall (2)
Only during the final recall (1)
No, during neither (8)

8. What did you find challenging during the recall trials?

Remembering the words because I memorized the melody
Words were not as fresh after the distraction task
Not enough repetition and was confused by the task
Remembering the order and all the words
Musicians – Spoken condition

1. What are some learning strategies you use to memorize information?
   Flash cards, repetition, mnemonic devices, writing information out, speaking out loud, study groups, reading, teaching,
   repetition, pictures, visuals, acronyms, color coding, and music.

2. What type of information do you use these learning strategies for?
   Word lists, phone numbers, names, study material, definitions, musical information, math equations, grammar rules, English
   and Spanish vocabulary, countries, capitals, and presidents.

3. How familiar with musical mnemonics are you?
   Very unfamiliar (1)
   Heard of it, but am unfamiliar (6)
   Heard of it, and slightly familiar (10)
   Very familiar (8)

4. Did you find the repetitive verbal rehearsal helpful in memorizing the word list?

<table>
<thead>
<tr>
<th>Yes (15)</th>
<th>No (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kind of</td>
<td>I like to read information out loud to memorize information.</td>
</tr>
<tr>
<td>Chant helped to chunk info; would be more effective w/ melody</td>
<td>Difficult to rehearse and process the words with the limited time.</td>
</tr>
<tr>
<td>Repetition helps me memorize information.</td>
<td>Hard to not memorize words visually and focus on recording.</td>
</tr>
<tr>
<td>I remember sounds well - auditory learner.</td>
<td>Just heard a bunch of words with no meaning.</td>
</tr>
<tr>
<td>Combinations of auditory and visual processes helps</td>
<td>Relied more on the word list.</td>
</tr>
<tr>
<td>Was presented in a pattern that was memorable</td>
<td>More of a visual learner.</td>
</tr>
<tr>
<td>Reinforced the words in my head while reading the list</td>
<td>Hardly used it.</td>
</tr>
<tr>
<td>BUT singing would have worked better</td>
<td>Distracting.</td>
</tr>
<tr>
<td>Helped remember the order of the words.</td>
<td></td>
</tr>
</tbody>
</table>

5. What did you find challenging about the recall?
   Unfamiliar with the words
   Not enough time to learn the words
   Recalling after the distraction task because I wasn’t thinking about the words for 10 minutes.
   Recalling the first word.
Recalling the order of the words.
Found the situation stressful.
Too many words
Recalling the words in the middle of the list.
Words were very random.

6. Did the word list provide a helpful visual aide? Why or why not?

<table>
<thead>
<tr>
<th>Yes (23)</th>
<th>No (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual learner</td>
<td>Writing them down while hearing them would have been more effective</td>
</tr>
<tr>
<td>Numbers helped me match the words.</td>
<td></td>
</tr>
<tr>
<td>More helpful than recording.</td>
<td></td>
</tr>
<tr>
<td>I have a photographic memory...kind of.</td>
<td></td>
</tr>
<tr>
<td>Able to look at the order and at own pace.</td>
<td></td>
</tr>
<tr>
<td>Helped because I was unfamiliar with the words.</td>
<td></td>
</tr>
</tbody>
</table>

7. Did you speak along to recording in your head during the presentation or during the recall?
Yes, during the presentation and during the recall (20)
Yes, only during the recall (2)
No, during neither (3)
Non-musicians – Spoken condition

1. What are some learning strategies you use to memorize information?
   Reading, repetitions, flash cards, pictures, musical mnemonics, mnemonic devices, incorporating info into real life situations, highlighting notes, rewriting notes, acronyms, study groups, outlines, and quizzing.

2. What type of information do you use these learning strategies for?
   Study materials, numbers, names, word lists, math equations, dates and times, procedures, vocabulary words, directions, planets, history, restaurant menu items, word lists, state names, and countries.

3. How familiar with musical mnemonics are you?
   Very unfamiliar (5)
   Heard of it, but am unfamiliar (10)
   Heard of it, and slightly familiar (8)
   Very familiar (2)

4. Did you find the repetitive verbal rehearsal helpful in memorizing the word list?

<table>
<thead>
<tr>
<th>Yes (18)</th>
<th>No (7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gave me more time to go over words and memorize them.</td>
<td>Would have been easier to memorize reading list w/out recording</td>
</tr>
<tr>
<td>Helped with pronunciation and order of words.</td>
<td>Distracting</td>
</tr>
<tr>
<td>Temporarily embedded in my brain.</td>
<td>More of a visual learner</td>
</tr>
<tr>
<td>Can remember the various sounds and words</td>
<td>Bland nature hampered memorization</td>
</tr>
<tr>
<td>For a short period of time.</td>
<td>Blocked out recording</td>
</tr>
<tr>
<td>Repetition helps stick info in my head</td>
<td>Reading without recording would let me go at my own pace</td>
</tr>
<tr>
<td>Good to hear the words.</td>
<td></td>
</tr>
<tr>
<td>Hearing and seeing something helps</td>
<td></td>
</tr>
<tr>
<td>Time in between each word provided time to process the info</td>
<td></td>
</tr>
<tr>
<td>Unfamiliar w/ words - the recording took focus off pronunciation</td>
<td></td>
</tr>
<tr>
<td>BUT more focused on the visuals</td>
<td></td>
</tr>
</tbody>
</table>

5. What did you find challenging about the recall?
   The distraction task took my mind off the words.
   Words that started with the same letter confused me.
   All the words were too long and blurred together.
   Recalling the order of the words.
The spelling of the words
Switching from math to English
Recalling the middle of the word list

6. Did the word list provide a helpful visual aide? Why or why not?

<table>
<thead>
<tr>
<th>Yes (24)</th>
<th>No (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual learner</td>
<td>Not enough to time to learn the list</td>
</tr>
<tr>
<td>Strong photographic memory</td>
<td></td>
</tr>
<tr>
<td>Helped with spelling</td>
<td></td>
</tr>
<tr>
<td>Helped with the order of the words</td>
<td></td>
</tr>
<tr>
<td>Helps more than just hearing it</td>
<td></td>
</tr>
<tr>
<td>Able to see and visualize the order of the words during recall</td>
<td></td>
</tr>
</tbody>
</table>

7. Did you speak along to recording in your head during the presentation or during the recall?
   Yes, during the presentation and during the recall (19)
   No, during neither (6)