EXPLICIT AND IMPLICIT MEMORY FOR MUSIC: AN INVESTIGATION OF SOURCE MEMORY, CONFIDENCE, AND THE MERE EXPOSURE EFFECT

by

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LIST OF ABBREVIATIONS

Abbreviation	**Description**
AD	Alzheimer’s Disease
MEE	Mere Exposure Effect
G	Gamma Correlations
JOL	Judgments of Learning

ABSTRACT

Past research into the use of musical mnemonics as an aid in memory enhancement has been somewhat limited and produced inconsistent results. The current study examined young adults and healthy older adults, with the goal of adding to the growing literature about the potential for music as a memory enhancer by investigating both explicit and implicit memory by presenting participants with sung and spoken stimuli. To investigate the effects of music on implicit memory, the mere exposure effect (MEE), or the tendency to like items previously encountered more than new items, was explored. Source memory and confidence ratings for explicit recognition memory judgments were also examined. For explicit memory, young adults were better at recognizing the sung recordings than the older adults, but there was little evidence of a memory benefit for sung compared to spoken conditions despite increased confidence in sung memory judgments for both groups. The mere exposure effect was found in the older adult group for the sung condition; however, young adults did not exhibit MEE for either condition. These results offer insight into how learning and memory differs between young adults and healthy older adults as well as provide more information about the potential of music as a memory enhancer.

I. INTRODUCTION

Music can serve as a successful mnemonic device for learning new information in young adults, healthy older adults, and patients with Alzheimer's disease (Calvert & Tart, 1993; McElhinney & Annett, 1996; Rainey & Larsen, 2002; Simmons-Stern, Budson, & Ally, 2010; Simmons-Stern, et al., 2012; Palisson, Roussel-Baclet, Maillet, Belin, Ankri, & Narme, 2015). However, the mechanisms and limitations of these musical mnemonics are not well understood. In this project, I investigated whether music could enhance different types of memory in young adults as well as in healthy older adults. By examining both young and older participants, I was able to not only contribute to our understanding of how music might enhance memory, but also detect changes in this relationship that occur as a result of healthy aging. The larger goal is to understand what leads to the best long-lasting memory for new information in both young and older adults.

Long-term memory is characterized as the ability to take in, store, and retrieve information about an event or item at a point later in time. Long-term memory has been categorized into two major types: explicit, or conscious, and implicit, or non-conscious, memory. Research has shown that explicit memory declines with age (Wilson et al., 2011), while implicit memory may be largely preserved in aging (Ward et al., 2013). Normal memory changes due to aging can affect long-term memories including occasional forgetting of names, where something was placed, appointments, or details of prior conversations (Schrauf & Iris, 2011). Explicit memory complaints in older adults have been correlated with poor quality of life, risk of depression, and functional limitations including reduced self-efficacy and inadequate social interaction (Rotenberg

Shpigelman, Sternberg, & Maeir, 2019). Considering that 40 million people in the United States are currently over the age of 65, with this number expected to double over the next thirty years (Kinsella & Wan, 2009), it is important to have efficient and effective memory enhancing strategies and techniques available.

The current study used a memory paradigm that measures both explicit and implicit memory in young adults and healthy older adults to further investigate whether music can be effectively used as a memory-enhancing strategy. Specifically, this study extends prior findings (Finch, Stern, & Deason 2019) by examining the potential that music can enhance source memory, a type of explicit memory for specific context information that is thought to decline even in healthy aging (Mitchell & Hill, 2019). Additionally, confidence in recognition judgments were examined to determine if confidence mirrored any potential differences between spoken and sung stimuli.

Implicit Memory

Implicit memory is memory for information obtained and used unconsciously that can affect feelings and actions. One type of implicit memory is the mere exposure effect (MEE), when an individual is more likely to favor an item that has been encountered before, even without conscious recollection (Zajonc, 1968). For example, you might not like a song the first time you hear it, but after several times of listening, you grow fond of the melody, lyrics and tune. Prior research into the mere exposure effect has utilized musical stimuli and found evidence of MEE in both young adults (Peretz, Gaudreau, &Bonnel, 1998; Schellenberg, Peretz & Vieillard, 2008; Szpunar, Schellenberg, & Pliner, 2004) and healthy older adults (Gaudreau & Peretz, 1999; Halpern & O'Connor, 2000).

Peretz, Gaudreau, and Bonnel (1998), examined both explicit and implicit memory for music in young adults. In the study phase of their experiment, participants listened to a set of both familiar and unfamiliar instrumental melodies. In the test phase, to measure implicit memory, participants heard both previously studied melodies as well as new melodies and rated on a 10-point scale how much they liked the stimuli. For the explicit memory recognition task, participants had to judge whether they had heard the melody during the study phase, thus intentionally retrieving the information. They found that by utilizing both a mere exposure task and a recognition task, implicit memory was successfully differentiated from explicit memory. By asking how the participants felt about the stimuli based on a liking scale, the mere exposure effect was elicited. Repeated exposure to the studied melodies led to an increase in liking for the unfamiliar melodies whereas there was an increase in recognition for the familiar melodies (Peretz, Gaudreau, & Bonnel 1998).

Further research conducted by Gaudreau and Peretz (1999), extended this paradigm to examine implicit and explicit memory in both healthy older adults and healthy young adults. Findings were congruent with their prior study (Peretz, et al., 1998) in that both groups displayed increased preference for studied compared with unstudied unfamiliar melodies, whereas both groups liked studied and non-studied familiar melodies equally well. Familiar melodies were more accurately recognized over the unfamiliar melodies, with the older healthy adults performing significantly worse than the young adults (Gaudreau & Peretz, 1999). These results provide evidence that the mere exposure effect is relatively spared during the aging process since both groups showed similar performance on this task, unlike the recognition memory task.

Schellenberg and colleagues (2008) were interested in how we come to like musical pieces as a function of prior exposure. Researchers found a curvilinear pattern for liking ratings that showed an increase in preference ratings followed by a decrease as a function of exposure. That is, participants' liking ratings increased after 2 exposures relative to baseline but were similar to baseline preferences after 8 exposures. Moreover, for participants exposed up to 32 times to the stimuli, liking ratings were actually lower than baseline. (Schellenberg, Peretz, & Vieillard, 2008). These finding suggest that at least 2 exposures to unfamiliar musical stimuli should be adequate to elicit the mere exposure effect in young adults.

Several studies have investigated the mere exposure effect in both healthy older adults and patients with Alzheimer's disease (AD; Deason et al., 2019; Halpern & O'Conner, 2000; Quiniam et al., 2003) Halpern and O'Connor (2000) examined implicit and explicit memory in young adults, healthy older adults and patients with AD. In their study, participants heard short, unfamiliar instrumental melodies and performed both a recognition task and a pleasantness rating. For encoding, participants listened to the melodies twice, and for the recognition test heard them a third time intermixed with new melodies. For the young adults, researchers found that memory in the recognition task was significantly greater than chance and increased preference for the old melodies showed the mere exposure effect. For the older adults, however, only the mere exposure effect was preserved. Patients with AD showed impaired explicit memory performance and a lack of the mere exposure effect (Halpern & O'Conner 2000).

However, Quiniam et al., (2003), found the MEE effect in both the older adults and the AD patients in their sample. As expected, explicit recognition memory was severely impaired within the AD patients when compared to healthy older adults. Similarly, Deason and colleagues (2019) found the mere exposure effect was present in both healthy older adults and patients with AD. MEE occurred for the vocals plus melody condition as well as an instrumental condition, but not for a spoken lyric condition, suggesting some advantage for implicit memory for musical stimuli in both groups. (Deason, Strong, Tat, Simmons-Stern & Budson, 2019).

These prior studies provide some evidence that implicit memory, specifically the MEE is relatively spared throughout the healthy aging process. They also show that differences in memory performance between younger and older adults appear to affect explicit recall and recognition memory in studies using musical stimuli (Gaudreau & Peretz, 1999; Halpern & O'Connor, 2000; Quiniam et al., 2003; Deason et al., 2019). To fully appreciate the effect that musical stimuli has on different types of memory, further examination of literature related to explicit memory and musical mnemonics will be explored.

Explicit Memory

Explicit memory is the conscious, effortful and intentional recollection of previously encountered information, experiences, facts, and concepts. Mnemonics, or memory aids, are specific tools that can assist in successful retrieval of previously learned or encountered material. Musical mnemonics include the use of song and melody in conjunction with the phrase or concept to-be-learned. A simple example of a musical mnemonic is the "ABC" song traditionally taught to learn the alphabet. Past research has investigated explicit memory in the context of musical mnemonics as an aid to enhance memory and the findings have been mixed (Calvert & Tart, 1993; McElhinney & Annett, 1996; Rainey & Larsen, 2002; Kilgour et al., 2000; Simmons-Stern, Budson, & Ally, 2010; Simmons-Stern et al., 2012; Palisson, et al., 2015).

Calvert and Tart (1993) conducted several studies that were designed to examine musical mnemonics and memory recall in both a naturalistic setting and an experimental setting. They wanted to investigate very-long-term memory, long-term memory, and short-term memory to determine if musical mnemonics used in the School House Rock television program that aired from 1976-1979 influenced performances on explicit memory recall tasks. Researchers used the episode that included the Preamble of the Constitution in their experiments (Calvert & Tart, 1993). The first part of the experiment asked young adult participants if they had watched the episode during their childhood and were asked to recall as much of the words to the Preamble as they could remember. This naturalistic design was used to measure very-long-term memory. They found that participants who had frequently viewed the Preamble episode had greater recall for the words of the text than did the infrequent viewers (Calvert & Tart, 1993). They created four conditions for conducting the experimental portion of the study on participants with no prior exposure: singing with repetition, verbal with repetition, singing without repetition, and verbal without repetition. The results showed that subsequent verbal recall of the Preamble was better for musical than spoken versions and the sung with repetition version of the Preamble resulted in better recall for the words when compared to the spoken with repetition version (Calvert & Tart, 1993). There was no statistically significant difference between the sung and spoken recall without repetition. The results of the studies suggested that musical mnemonics may be beneficial for verbatim recall.

Further research used a similar paradigm in young adults to measure explicit recognition memory by using words that were either in a sung or spoken condition (McElhinney & Annett, 1996). They found that recall was better for the words that were in the sung condition compared to the spoken condition (McElhinney & Annett 1996). Similarly, Rainey and Larsen (2002) conducted two experiments that required participants to learn a list of names that were heard either spoken or sung to a familiar tune. The first experiment used the melody of "Pop Goes the Weasel", whereas in experiment two the melody of "Yankee Doodle" was used. Both studies looked at the number of trials participants needed to learn the list of names initially as well as how many trials needed to relearn the list a week later. For both studies, initial learning showed no advantage for either sung or spoken conditions, however the number of trials needed to relearn the list a week later was significantly different for the two conditions, with the sung version requiring less trials (Rainey & Larsen, 2002). These results provided support for the effectiveness of musical mnemonics.

While the previous studies examined evidence of musical mnemonics as an aid for memory enhancement, other studies have found contradictory evidence (Kilgour et al., 2000). Kilgour et al. (2000) predicted that the memory benefit previously found for musical mnemonics was due to the duration or presentation rate of the song versions versus the spoken versions. To control for presentation rate, sung and spoken stimuli were manipulated to have equal durations. They found that before the manipulations, participants had a greater memory recall for the sung condition, however after the duration was equated, recall for both sung and spoken lyrics was the same (Kilgour et al., 2000). This suggests that duration of exposure to the sung conditions may be a contributing factor to enhanced memory recall and not necessarily the musical mnemonics.

The previous studies provided evidence of musical mnemonics contributing to better memory recall in young adults, although some of the results were mixed. More recently, the use of musical mnemonics has been examined in healthy older adults and patients with Alzheimer's disease (AD). Simmons-Stern and colleagues (2010) were the first to experimentally investigate the role of music as a memory enhancer in healthy older adults and in patients with AD, whose explicit memory is severely impaired. In general patients with AD are less likely to recall the vivid details of an event and may need to rely more on a contextual sense of familiarity to make memory judgments (El Haj et al., 2020). The research conducted by Simmons-Stern and colleagues (2010, 2012) sought to answer several questions related to musical mnemonics and memory. In the 2010 study, researchers found that patients with AD had better recognition for visual lyrics when accompanied by sung rather than spoken recordings during encoding. However, the older adults showed a benefit of the musical encoding. Further research conducted by Deason et al. (2012) added in a one-week delay between encoding and testing for older adults and found no significant difference in memory performance for lyrics that were either sung or spoken during encoding even with a one-week delay. Overall, these studies provide evidence that musical mnemonics may aid memory performance in patients with AD, but that this benefit may not always extend to healthy older adults.

To build on and further explore the use of music as a memory enhancer Simmons-Stern and colleagues (2012) investigated two types of recognition memory: recollection and familiarity. Recollection is characterized as a rich detailed memory for specific information of a previously encoded event (Yonelinas, 2002). In contrast, familiarity is a larger awareness of knowing something without the proper contextual outline of the event (Yonelinas, 2002). Healthy older adults and patients with AD participated in a memory task that tested both recollection memory and familiarity for novel lyrics related to instrumental activities of daily life that were either sung or spoken. The participants were first presented with a question asking about the general content of the lyrics heard to examine familiarity (i.e. "Did you hear lyrics about pills?"). They were then asked to recognize specific information from the lyrics to examine recollection (i.e. "What did the lyrics say to do with the pills?"). The results of this experiment seem to suggest that there was similar performance across sung and spoken conditions for specific information; however, both groups performed significantly better on the sung conditions for the general content questions (Simmons-Stern et al., 2012). These findings provide evidence that music may have the potential to increase information that tends to be more general in nature and utilizes familiarity-based memory, whereas musical encoding may not be as useful for enhancing more specific content information (Simmons-Stern et al., 2012).

Contrary to what Simmons-Stern et al., (2012) found, research by Palisson et al., (2015) provided evidence that music has the ability to improve not only familiarity, but also specific content recollection (Palisson, et al., 2015). In their study, Palisson and colleagues (2015) had healthy older adults and patients with AD learn texts presented as either sung or spoken. Recall was measured either immediately or after a 5-minute delay. In both recall conditions, both groups showed greater memory for the sung texts over the spoken texts. Additionally, the AD patients showed a robust benefit for the musical condition, with more than 90% of the AD sample showing the advantage to the sung content for number of lines learned, both in the immediate and delayed recall (Palisson et al., 2015). Taken together, the studies conducted by Simmons-Stern et al. (2010, 2012) and Palisson et al. (2015) show that musical mnemonics may be an effective strategy for learning and remembering novel information in both older adults and patients with AD, but further research is necessary to fully understand this potential.

Source Memory

Source memory, a type of explicit memory, is a person's ability to correctly identify the origin of prior knowledge and information. Source monitoring strategies allow individuals to use both external and internal cues to accurately determine the source of a memory or idea. For example, external source monitoring might aid in the recall of what outfit a person wore to a Christmas party whereas internal source monitoring might help that person distinguish between an idea they thought to themselves or said out loud. While these source monitoring strategies are largely unconscious processes and can lead to memory errors (Loftus & Hoffman, 1989), several retrieval monitoring strategies have been shown to reduce false memories and increase accurate source memory recall and recognition (Dodson & Schacter, 2002; Palumbo, Mammarella, Di Domenico, & Fairfield 2018; Mitchell, Sullivan, Schacter, & Budson, 2006).

Research has found that young adults use two types of source monitoring strategies: diagnostic monitoring and metacognitive control (Dodson & Schacter, 2002). Diagnostic monitoring, considered a distinctiveness heuristic, occurs when a person uses *diagnostic* evidence, based on expected distinctive characteristics of an item or event, to either confirm or reject the source of the memory. Metacognitive control is a person's expectation that they should be able to remember the distinctive information for the source of the event or item and appears to work congruently with diagnostic monitoring (Dodson & Schacter, 2002). When compared to young adults, older adults focus less on perceptual diagnostic information when making memory judgments, instead, relying more on affective states involving semantic, conceptual or emotional information (Gallo, 2013).

In a series of studies, Dodson and Schacter (2002) had young adult participants study lists of pictures and words and were later tested on only the word list. When participants were told they would not be tested on the pictures, diagnostic monitoring did not occur, and instances of falsely recognized words were significantly higher. However, when participants were incorrectly informed that all items would be present in the test phase, they showed metacognitive control and correctly rejected the new words in the list (Dodson & Schacter, 2002). The absence of memory for a distinctive, expected item allowed participants to use a metacognitive technique to correctly identify a test item as novel. These findings provide evidence of source monitoring strategies being used in young adults when recognizing pictures or words.

Palumbo and colleagues (2018) were interested in whether or not age-related deficits in source monitoring could be attenuated by listening to music during encoding for a source memory test. In the study, both young and older adult participants viewed 2 lists of emotional pictures presented on either the right side or the left side of the computer screen. During encoding, participants listened to background audio tracks of either classical music or white noise. For half of the pictures, participants were asked if the pictures were located on the left or right of the screen or if the picture was new. For the other half of the pictures, participants were asked if the picture appeared on list one, list two, or were new. Results showed that older adults remembered better and had greater accuracy in the source monitoring task after listening to classical music compared with white noise. Overall, however, older adults performed poorer in the source monitoring task when compared to younger adults (Palumbo, et al., 2018). These results provide evidence that musical stimuli may help improve source monitoring in both young and older adults.

Prior research into source monitoring in healthy older adults and patients with AD has provided evidence that source memory is diminished in patients with mild AD (Pierce, Waring, Schacter, & Budson, 2008). However, Deason and colleagues (2017) found that when patients were instructed and encouraged to use a metacognitive retrieval monitoring strategy during a test phase the patients exhibited improved memory performance (Deason et al., 2017). The previous studies on young adults, older adults, and patients with AD have provided evidence that source monitoring strategies, such as diagnostic monitoring and metamemory control are successful in helping participants accurately identify the source of previously encoded items and information (Dodson & Schacter, 2002; Palumbo, et al., 2018; Mitchell, et al., 2006). However, there are apparent differences in source memory performance and source monitoring strategies between young and older adults (Palumbo, et al.,2018). While music has been shown to increase source accuracy in both young and older adults (Palumbo et al., 2018), more research is necessary to establish the efficacy of using musical mnemonics to enhance source memory strategies.

Confidence in Memory Judgments

Metamemory, like metacognitive control techniques, is the awareness and knowledge of one's own memory capabilities as well as one's own extrinsic knowledge of different memory aid strategies involved in memory monitoring. Previous research has explored confidence judgments as a function of metamemory and found that correctly answered questions are more confidently rated than incorrectly answered questions (Siedlecka, Skóra, Paulewicz, Fijałkowska, Timmermans, & Wierzchoń, 2018; Saito, 1998; Ladowsky-Brooks, 2018; Wong, Cramer, & Gallo, 2012). One of the aims of the current study is to gain insight into changes that occur as a result of aging and how these changes might affect metamemory judgments. Past research examined the relationship between recollection accuracy and ensuing confidence judgments in younger and older adults (Wong, et al., 2012). In their study, participants made recognition judgments based on previously encoded pictures and words. Recollection test accuracy was compared to confidence judgments for assessing metamemory accuracy and found young adults had higher recollection test accuracy and metamemory accuracy than the older adults. Additionally, both groups had higher confidence and recollection accuracy in the picture condition when compared to the word condition (Wong et al.,2012). The results suggest an age-related reduction in the relationship between confidence and accuracy, with older adults less confident in their accuracy performance. Additionally, these differences between age groups might be attributed to metamemory monitoring of their overall memory abilities.

Additionally, past research has investigated judgments of learning (JOL), or how well a person believes they have learned new or certain pieces of information, to gain insight into memory monitoring and accuracy in memory recall tests. One common way to assess relationship between metamemory and memory accuracy is by using nonparametric correlational measures between predicted and actual test performances for each participant (e.g., Kelemen, 2000). Gamma correlations (*G*) can be used as an index of metamemory accuracy (Nelson, 1984), where any number above 0 indicates a greater than chance relationship between two variables. Kelemen (2000) asked participants to study items from different categories and then rated how certain they were to accurately recall items in each category later in a test phase. The research found that participants were able to monitor their memories at a level greater than chance, as Gamma values were at a level significantly higher than 0 (Kelemen, 2000).

In a study to investigate the brain regions associated with recognition memory and confidence, Yokoyama and colleagues (2010) found confidence ratings and recognition accuracy varied widely between young adult participants. Subjects were required to memorize a sample image and then after a delay, they rated how confident they were (high, medium, or low) that they would recognize the image during a test phase. Gamma correlations were calculated for each participant to determine the relationship between recognition memory performance and confidence ratings. Post-hoc tests showed that the high-confidence trials were significantly higher in correct recognition memory performance than the middle and low confidence trials (Yokoyama et al., 2010).

Prior research conducted in our lab looked at confidence judgments for old/new recognition judgments and source memory accuracy (Finch, Stern, & Deason, 2019). In the first experiment we had young adult participants listen to sung and spoken audio recordings accompanied by the lyrics on the computer monitor. For the recognition test, participants listened to both old and new sung and spoken recordings, however, the lyrics were no longer visually presented. After each old/new recognition judgment, participants rated how confident they were with their recognition decision. We found that explicit recognition memory was significantly higher for the sung compared to the spoken recordings, and additionally that there was greater confidence for correctly identified sung stimuli compared to correctly identified spoken stimuli (Finch, Stern, & Deason, 2019).

In the second experiment, young adult participants followed the same encoding procedure as our first experiment. However, in the test phase, participants were shown old and new lyrics on the computer monitor with no audio accompaniment. To measure source memory, participants decided if they had heard the lyrics during encoding, and if so, how they heard them (sung or spoken). After participants made their source memory judgment, they rated their confidence in that decision. First, we found a greater source identification for the sung lyrics when compared to the spoken lyrics, and as predicted, found that confidence was significantly higher for the sung correct responses compared to the spoken correct responses (Finch, Stern, & Deason, 2019). These two experiments suggested young adults showed a benefit for music when making explicit memory judgments and that music may be an effective strategy for increasing memory performance as we age. For this reason, the current study was intended to examine source memory in both young adults and healthy older adults.

Current Study

For the current study, we used and expanded on important aspects of our prior design (Finch, Stern, & Deason, 2019) including the use of musical stimuli to investigate source memory and confidence in source memory judgments. Additionally, a preference task was used to test if the mere exposure effect is present in both young and older adults, and if sung musical stimuli results in a larger MEE than spoken stimuli. For the source memory task, we tested to see if music can aid in the successful retrieval of previously encoded musical stimuli in both young adults and healthy older adults. We also examined the role of confidence while making recognition memory judgments, with the understanding that confidence in metamemory decreases as we age (Wong, et al., 2019).

Explicit Memory Hypotheses

The first hypothesis for the explicit memory tasks was that participants, both young adults and older adults, would have greater recognition accuracy for sung lyrics versus spoken stimuli conditions. The second hypothesis was that older adults would have lower overall rates for correct source memory judgments when compared to younger adults; however, we predicted better source memory for the sung musical stimuli versus the spoken musical stimuli. Lastly, the third prediction was that participants would be more confident in their judgment for sung lyrics over spoken lyrics when making those decisions.

Implicit Memory Hypotheses

In the implicit memory task, we predicted that participants would demonstrate a mere exposure effect, having a greater preference for “old” compared to “new” stimuli. We also predicted that older adults will have a greater effect for MEE than the younger adults and that both groups will show a larger MEE for the sung recordings compared to the spoken recordings.

II. METHOD

Participants

For this study, 55 young adults (M_{age}=18.87, SD_{age}=1.13, 74.4% female) and 38 older adults (M_{age}=63.47, SD_{age}=8.54, 71.1% female) were recruited. Young adults were recruited through the Texas State SONA System recruiting pool. Older adult participants were recruited through outreach programs, flyers posted in approved sites, and online advertising. For young adults, course credit was given for participation and older adults, were compensated $10 an hour for their participation. All participants had normal or corrected-to-normal vision and hearing to ensure optimal processing of the stimuli. Procedures were approved by the Institutional Review Board at Texas State University.

Measures and Instruments

The experiment was conducted using ePrime presentation software (Psychology Software Tools, Pittsburgh, P.A.) and consisted of auditory recordings recorded by a male vocalist from Texas State University. The audio recordings included 96 novel, unfamiliar sets of lyrics recorded as both sung and spoken versions separately, resulting in 192 auditory recordings total. For example, “Pigs play in mud and have squiggly tails, they love to sleep and drink from pails.” Sung versions of the lyrics were accompanied with instrumental background melodies, while spoken versions of the lyrics had no accompaniment. To counterbalance the stimuli across conditions and participants, 8 versions of the experiment was administered using the same stimuli but in different rotations through conditions. Counterbalanced lists were created by equating conditions based on 9 different variables: sung duration, spoken duration, difference between sung and spoken duration, major/minor keys, beats per minute, word length, word count, and word frequency.

Healthy older adults were given the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) which includes several cognitive functioning tasks: visuospatial and executive function, naming, memory recall, attention, language, abstraction, delayed recall and orientation tasks. Higher scores on the MoCA indicated better cognitive ability. Both young adults and older adults were given the Goldsmith Musical Sophistication Index (Gold-MSI; Mullensienfen et al., 2014) to assess their prior musical experience.

Procedure

The experiment was conducted in a laboratory or a place convenient to the participants and took approximately 1.5-hours to complete. Each session included an encoding phase, implicit memory test phase, and a source memory test phase. Participants used noise canceling headphones to listen to the sung and spoken audio stimuli. The volume was adjusted accordingly per participants' comfort level prior to beginning the practice phase. Participants listened to a total of 48 audio recorded stimuli repeated twice in the experiment. Overall, there were four phases within the experiment (in order): an encoding phase one, implicit test phase, encoding phase two, and an explicit test phase. For the first three phases of the experiment, the lyrics were visually presented alongside the audio recordings. In the last (explicit test) phase, the lyrics were presented on the screen without the audio recordings.

First, for encoding phase one, participants were asked to listen to and were visually presented with 24 audio recordings and lyrics: 12 spoken stimuli and 12 sung stimuli: after each stimulus presentation they were asked to make a judgement on a scale of 1 to 4 as to whether the stimuli were positive or negative, one being completely negative and four being completely positive. Participants were directed to make their negative/positive judgment based on how the lyrics made them “feel”. Next, to measure implicit memory, using the mere exposure effect, participants listened to and rated 48 audio recordings: 24 “old” (12 sung and 12 spoken) and 24 “new” (12 sung and 12 spoken). After each recording, participants made a preference judgment and rated on a scale of 1 to 4 how much they liked the sung or spoken stimuli. One being “dislike a lot” and 4 being “like a lot”. Next, to equate number of exposures, in the encoding phase 2, participants listened to and rated the 24 stimuli that were new in the implicit memory test phase for negative and positive judgments. After the data for the first 3 young adults participants were analyzed, it was apparent that source accuracy was reaching ceiling. To reduce the presence of a ceiling effect, young adults were given a 5-minute distractor task between the second encoding phase and the subsequent explicit test phase.

Last, in the explicit test phase, participants viewed 96 different lyrics presented on the screen with no auditory accompaniment: 48 “new” or unheard in the encoding phase and 48 “old” or heard in the encoding phase (half heard previously as spoken, half heard previously as sung). Participants made an explicit source recognition memory judgment and pressed 1 if the lyrics were “new” or unheard and pressed 2 if the lyrics were “sung” and pressed 3 if the lyrics were “spoken”. After the source memory judgment, participants rated on a scale of 0 to 100, how confident they were that the stimuli presented was either “sung”, “spoken” or “new”. After the test phase was complete, participants filled out the MoCA (healthy older adults) and Gold-MSI (both groups), a post-experiment questionnaire, debriefed and allowed to leave.

III. RESULTS

Explicit Memory Analysis

To determine if there was a difference between young adults and older adults for source memory accuracy between the sung and spoken conditions, a 2X2 repeated measures ANOVA was conducted, with lyric condition as the within-subjects factor and age group as the between-subjects factor. We found no significant main effect for the lyric condition, $F(1,91)=2.260$ $p=.136$, however, there was a marginally significant interaction between source accuracy and age group, $F(1,91)=3.375$, $p=.069$. A follow-up analysis with a paired samples t-test comparison between the source accuracy conditions for the older adults showed marginally higher accuracy for the spoken condition ($M=.626$, $SD=.151$) than the sung condition ($M=.535$, $SD=.177$), $t(37)=1.902$, $p=.065$. Meanwhile, young adults showed no significant difference between the spoken ($M=.682$, $SD=.176$) and sung condition ($M=.691$, $SD=.181$), $t(54)=-.293$, $p=.770$ (see Table 1 and *Figure 1*). There was a main effect for age, $F(1,91)=18.967$, $p<.001$, $\eta^2_p=0.17$. A follow-up pair-wise comparison showed young adults had significantly higher accuracy for the sung condition compared to the older adults $t(91)=4.133$, $p<.001$ (see Table 1). There was not a significant difference in accuracy for the spoken condition between the two groups $t(91)=1.589$, $p=.115$.

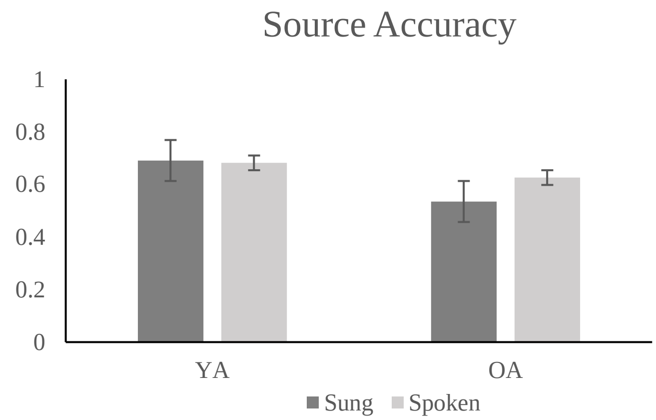

Figure 1. Source Accuracy. Mean values of source accuracy in the sung and spoken conditions for young adults (YA) and older adults (OA).

We also examined overall old/new accuracy rates for the explicit memory task. Source responses from the test phase for the sung and spoken items were recoded for "old" accuracy. If the response was "new", it was considered a false alarm and coded as incorrect or "0". If the response was either sung or spoken it was considered a correct response and coded as correct or "1". Neither group showed significant differences between spoken and sung old accuracy, YA: $t(54)=-.423$, $p=.674$, OA: $t(37)=1.227$, $p=.228$. One important finding to note: both young adults and older adults had very high overall accuracy in both conditions (over 95%; see Table 2). These high overall accuracy averages suggest that participants were near maximum performance, resulting in a ceiling effect.

Confidence Ratings Analysis

Confidence scores were analyzed in two separate ways. First using accuracy-confidence scores and second examining Gamma correlations. To start, raw confidence scores were totaled for each participant on each trial for the sung correct responses, sung incorrect responses, spoken correct responses and spoken incorrect responses. A 2X2 repeated measures ANOVA was conducted to examine if confidence associated with correct responses, with lyric condition as the within-subjects factor and age group as the between-subjects factor. We found a significant difference for confidence ratings between the lyric conditions, $F(1,91)=7.639$, $p=.007$; participants had higher confidence in the correct sung condition ($M=80.98$, $SD=14.98$) than the correct spoken condition ($M=77.74$, $SD=16.26$) for correct memory judgments, $t(92)=-2.902$, $p=.005$. There was no significant interaction between lyric condition and age group, $F(1,91)=.176$, $p=.676$ and no significant difference in confidence ratings for correct responses between age groups $F(1,91)=.186$, $p=.667$ (see Table 1 and *Figure 2*). For the incorrect responses, an analogous 2X2 repeated measures ANOVA was conducted, which showed no significant difference for confidence ratings between the lyric conditions $F(1,89)=3.040$, $p=.085$. There was also no significant interaction $F(1,89)=.001$, $p=.970$, and only a marginally significant differences between age groups $F(1,89)=3.211$, $p=.077$. For the incorrect responses, older adults had higher overall confidence ratings for both sung and spoken conditions when compared to the young adults (see Table 1 and *Figure 2*).

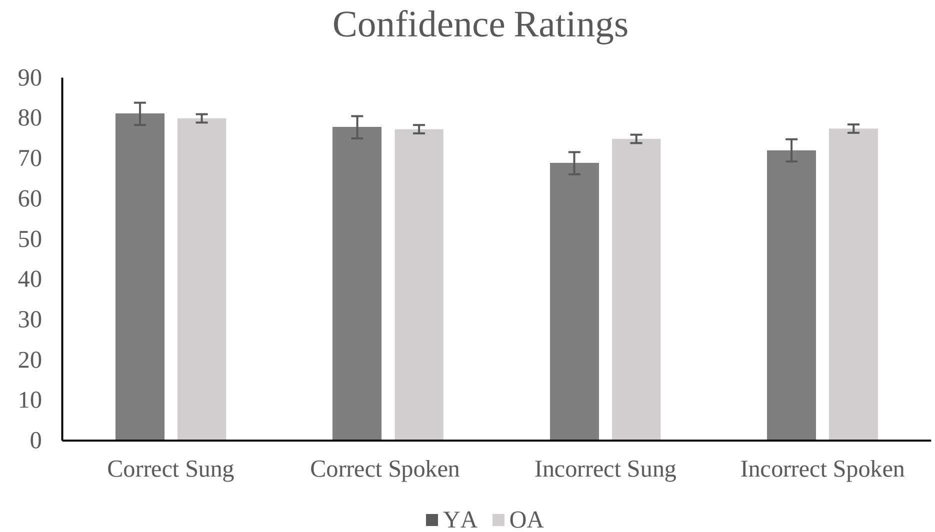

Figure 2. Confidence Ratings. Mean values of confidence ratings from sung and spoken conditions for young adults (YA) and older adults (OA).

Next, Goodman-Kruskal Gamma (*G*) correlations were calculated to measure the relationship between confidence ratings and recognition accuracy for each participant by condition. A 2X2 repeated measures ANOVA was conducted, with lyric condition as the within-subjects factor and age group as the between-subjects factor. There was a statistically significant difference in metamemory accuracy between the sung and spoken conditions, $F(1,86)=2.495$, $p=0.013$. Metamemory accuracy was higher for the sung condition as compared to the spoken condition. There was a significant main effect of age, $F(1,86)=6.141$, $p=0.015$, young adults had significantly higher mean *G's* in both conditions compared to the older adults. There was no significant interaction between lyric condition and age group, $F(1,86)=.239$, $p=0.626$.

In addition, one sample t-tests for the mean *G*'s of each condition were used to measure if Gammas were significantly different from 0, or chance. This analysis addresses whether or not participants were able to monitor their performance at a level greater than chance within each condition. Young adults showed significant differences in the sung condition, $t(51)=6.217$, $p<0.001$, as compared to 0, or chance, as well as significant differences in the spoken condition, $t(52)=2.751$, $p=0.008$, as compared to 0, or chance. Additionally, older adults were significantly different than 0 in the sung condition, $t(35)=3.434$ $p=0.002$, yet showed no significant difference from 0 for the spoken condition $t(35)=.031$, $p=0.975$.

Correlational analyses were conducted to see if a relationship existed between the sung and spoken accuracy conditions and the participants musical sophistication, as measured by the Goldsmith Musical Sophistication Index (Gold-MSI; Mullensienfen et al., 2014). Higher scores on the Gold-MSI indicate higher musical sophistication. For the young adults no significant relationship was found, for either the sung accuracy, $r(1,53)=.047$, $p=.736$, or spoken accuracy $r(1,53)=.104$, $p=.449$. Similarly, in the older adults, there was no significant relationship between the sung accuracy, $r(1,36)=.017$, $p=.919$, or spoken accuracy $r(1,36)=-.039$, $p=.817$. These results suggest that prior musical knowledge showed no relationship to how well a participant performed during the explicit test phase of the experiment.

Implicit Memory Analysis

To establish if the mere exposure effect was found, raw preference scores for each trial were recoded (based on procedures used in Deason et al., 2019): a preference rating of a 1 or 2 was changed to a "1" (dislike) and a preference rating of a 3 or 4 was changed to a "2" (like). Next, a MEE score was computed by subtracting each participant’s “old” preference ratings from the new preference ratings for each condition, which resulted in a

MEE sung score and a MEE spoken score calculated for each individual. A 2X2 repeated measures ANOVA was conducted, with lyric condition as the within-subjects factor and age group as the between-subjects factor. The analysis showed no significant interaction between condition and age group, $F(1,91)=.215$, $p=.644$ as well as no main effect for age, $F(1,91)=1.757$, $p=.188$. However, there were statistically significant differences for the lyric condition, $F(1,91)=5.450$ $p=.022$, $\eta^2_p=.057$ (see *Figure 3*). Follow-up analysis to examine the main effect of lyric condition were performed using a paired samples t-test and found the MEE scores were significantly higher for the sung recordings when compared to the spoken recordings $t(92)=2.298$, $p=.024$ (see *Figure 3*). Paired sample t-tests for the MEE scores were conducted to see if differences exist between MEE sung scores and MEE spoken scores in each of the age groups. The young adults showed no difference, $t(54)=1.402$, $p=.167$, however, the older adults showed marginally higher sung MEE scores than spoken MEE scores $t(27)=1.951$, $p=.059$.

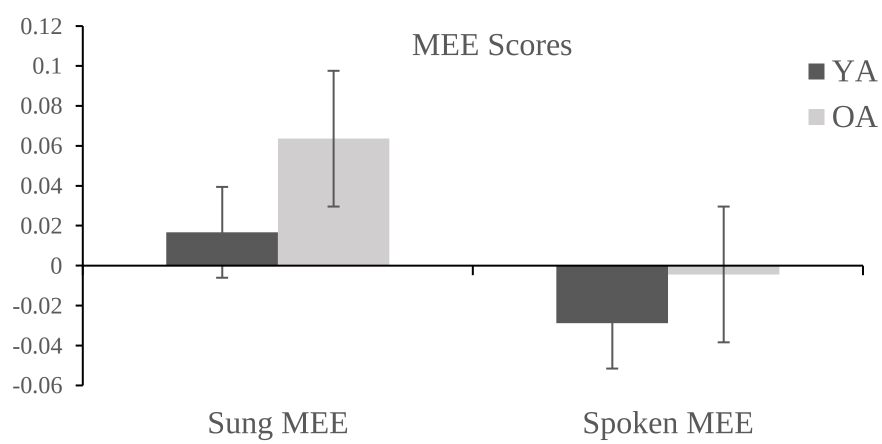

Figure 3. MEE Scores. Mean values for MEE scores, from sung and spoken conditions for young adults (YA) and older adults (OA).

To determine if participant's MEE scores were related to their source accuracy, correlational analysis were performed for each group. Young adults showed no association between MEE scores and source accuracy for the sung condition $r(1,53)=-.056$, $p=.683$ or spoken condition $r(1,53)=-.184$, $p=.179$. Older adults also showed no relationship between MEE score and source accuracy for the sung condition $r(1,36)=.130$, $p=.435$. The older adults, however, did show a significant negative relationship with their spoken MEE score and spoken source accuracy, $r(1,36)=-.347$, $p=.033$, $R^2=.120$. As spoken source accuracy decreased, MEE spoken scores increased.

To determine if participant's overall liking of the stimuli had an association with their source accuracy, we computed average preference ratings for the "old" sung and the "new" sung recordings for a total sung preference rating score. We also computed a total score for the "old" spoken and "new" spoken for a total spoken preference score. We found a significant positive correlation in young adults between the total sung preference ratings and sung accuracy scores, $r(1,53)=.291$, $p=.031$, showing that as preference ratings for the sung recordings increased, source accuracy for the sung recordings increased. Conversely, there was no significant relationship found for the spoken preference ratings and spoken accuracy for the young adults, $r(1,53)=-.139$, $p=.736$. Analogous correlations were also conducted for the older adults and found no relationship between the sung preference scores and sung accuracy, $r(1,36)=.010$, $p=.954$, or the spoken preference scores and spoken accuracy, $r(1,38)=-.139$, $p=.404$ (See *Figure 4.)*

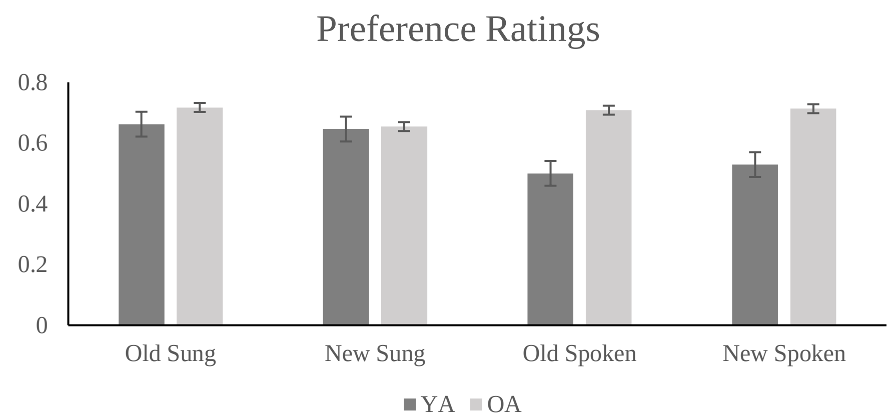

Figure 4. Preference Ratings. Mean values for preference ratings, from sung and spoken conditions for young adults (YA) and older adults (OA)

Table 1.
Mean values and standard deviations for source accuracy, preference ratings and confidence ratings

Source Accuracy	*Group*	*Mean*	*Standard Deviation*
Spoken Accuracy	YA	.682	.176
	OA	.626	.151
Sung Accuracy	YA	.691*	.181
	OA	.535*	.178
Preference Ratings			
Old Spoken	YA	.500	.249
	OA	.708	.232
New Spoken	YA	.529	.240
	OA	.713	.238
Old Sung	YA	.662	.203
	OA	.717	.216
New Sung	YA	.646	.222
	OA	.654	.228
Confidence Ratings			
Correct Spoken	YA	77.699	17.085
	OA	77.227	15.057
Correct Sung	YA	81.031	14.521
	OA	79.902	15.512
Incorrect Spoken	YA	71.972	18.109
	OA	77.369	15.746
Incorrect Sung	YA	68.787	17.891
	OA	74.825	16.689
Spoken Gamma	YA	.214	.566
	OA	.003	.621
Sung Gamma	YA	.394	.457
	OA	.292	.549

Notes: YA=Young Adults, N=55; OA=Older Adults, N=38**.**

Table 2.
Mean values and standard deviations for overall old/new accuracy

Overall Accuracy	*Group*	*Mean*	*Standard Deviation*
Spoken Accuracy	YA	.965	.063
	OA	.984	.036
Sung Accuracy	YA	.968	.058
	OA	.976	.047

Table 3.
Mean values and standard deviations for Gamma (G) correlations

Gamma Correlations (*G*)	*Group*	*Mean*	*Standard Deviation*
Spoken Gamma	YA	.214	.566
	OA	.003	.554
Sung Gamma	YA	.394	.457
	OA	.292	.511

IV. DISCUSSION

The purpose of our study was to further explore the benefits of using musical mnemonics to help aid in new learning and long-term memory in young adults and older adults. Our experiment was designed to test both explicit and implicit memory in healthy individuals to give us insight into how this potential benefit might change as we age. We found evidence that was both consistent with, and contradictory to previous research and each hypothesis will be addressed and explained within the sections below.

Explicit Memory

First, we hypothesized that, for the explicit source memory task, participants would have greater source recognition accuracy for the sung versus spoken lyric condition. We found that young adults showed no difference in source memory accuracy between the sung and spoken conditions; however, young adults had significantly higher accuracy than older adults in the sung condition, but not the spoken condition. Furthermore, contrary to what we predicted; older adults showed marginally higher accuracy when recognizing the source in the spoken lyric condition than that of the sung condition. We also predicted that older adults would have lower overall accuracy when compared to the young adults, and while we did find this to be true in the sung condition, both groups performed similarly on the spoken condition. Additionally, when considering the overall old accuracy for the sung and spoken condition, there was no difference between the two groups.

Gaudreau and Peretz (1999) found similar results, when they showed that melodies were more accurately recognized by young adults than older adults. Their findings, along with the current findings help highlight that there are important differences in the way young adults and older adults process and recognize previously encountered information. One possible explanation for why older adults performed better for the spoken condition compared to the sung has to do with the complexity of the sung stimuli. Kilgour and colleagues (2000) found that participants had a greater memory recall for the sung condition; however, once duration was equated, recall for both sung and spoken lyrics was the same. In our current experiment, we controlled for presentation rate by recording the spoken version of the lyrics to match the duration of the sung version. It is possible, for older adults, the exaggerated pauses, extended annunciations and overall sharper word connotation provided a memory boost resulting in greater accuracy for the spoken recordings. Alternatively, correlational analysis in the current study showed that as older adults' preference for the spoken stimuli decreased, their spoken source accuracy increased. It is possible that for older adults, the exaggerated pauses, extended annunciations and overall sharper word connotation provided a memory boost resulting in greater accuracy for the spoken recordings.

Furthermore, the current procedure was designed to have multiple encoding phases in order to measure implicit memory, and as a result, overall accuracy was near ceiling. Prior studies using a similar musical paradigm showed higher accuracy for the sung stimuli (Finch, Stern, & Deason, 2019); however, the overall old/new accuracy did not reach the high values that we saw in our current design. One of the differences in procedure between our previous studies was the number of exposures the participants experienced prior to the test phase. In our current study, participants were exposed to each sung and spoken recording twice, whereas the previous studies included only one exposure (Finch et. al., 2019). This additional exposure may be responsible for the overall higher old/new accuracy we saw in both groups, as well as the absence of differences for the sung versus spoken source accuracy in the young adults. Potentially, there is less opportunity to show increases related to the use of musical mnemonics if performance is already at such a high level.

Likewise, Simmon-Stern and colleagues (2012) found evidence that music has the potential to increase information that tends to be more general in nature and utilizes familiarity-based memory. For our experiment, the musical and spoken recordings were novel in nature and never heard before. This was done to control for familiarity; however, it is possible that the benefit for music in older adults, especially, are more pronounced for melodies that are indeed familiar in nature with extensive previous experience and links to memories.

Another possible explanation for the source recognition accuracy findings may be potential differences in how source monitoring frameworks change as we age. As previously discussed, source monitoring strategies can contribute to an individual's ability to correctly identify the source of previously encoded information. Deason and colleagues (2017) found that when patients with AD were instructed and encouraged to use a metacognitive retrieval monitoring strategy during a test phase the patients exhibited improved memory performance. It might be the case, that for older adults, source monitoring strategies should be explained and encouraged during the encoding phase to achieve greater accuracy for source recognition in the test phase. It is possible that older adults might have done significantly better in the sung condition if they were told before the experiment began that they would have to remember if the lyrics were sung or spoken and urged to use specific source monitoring strategies.

Confidence in Memory Judgments

For explicit memory judgments, we hypothesized that both young adults and older adults would be more confident in their responses for the sung condition when compared to the spoken condition. This was shown to be the case for the young adults, who rated their confidence for their accurate sung responses significantly greater than their accurate spoken responses, despite performing equally on both conditions. These findings confirm previous research that showed correctly answered questions are more confidently rated than incorrectly answered questions (Ladowsky-Brooks, 2018). Moreover, older adults rated their accurate sung responses with greater confidence than their accurate spoken response. Although older adults had marginally higher source accuracy in the spoken condition, their overall confidence ratings were higher in the sung condition when compared to the spoken.

In line with past research (Kelemen, 2000), we found support for the hypothesis that both young adults and older adults show greater confidence in the sung condition when compared to the spoken. Additionally, Gamma correlations showed that participants had higher metamemory accuracy for item-by-item judgments for sung compared to spoken stimuli. These findings are interesting, in that participants, regardless of recognition performance, showed higher confidence when making sung memory judgments compared with the spoken judgments. This could provide evidence that even though the actual performance in sung condition did not reflect a boost for musical encoding, there were some differences in metamemory related to the musical encoding. In other words, if there is some metacognitive belief about the benefits for encoding of musical information, in some cases it does not lead to measurable memory performance differences. Additionally, our post-experiment questionnaire and debriefing showed that both groups of participants felt that they did better at recognizing the sung lyrics; however, they also expressed difficulty in making source judgments for old lyrics, but had no trouble recognizing the lyrics that were new, as shown by their overall “new” accuracy averages: OA=0.989, YA=0.944. It appears that music influences confidence ratings for memory judgments and further research is needed to tease apart the mechanisms that drive individuals to feel more confident when making memory judgments related to musical stimuli.

Implicit Memory and the Mere Exposure Effect

We predicted that participants would demonstrate a mere exposure effect, reflected by greater preference for old lyrics compared to “new” lyrics. Furthermore, it was predicted that older adults would show a greater effect for MEE than the younger adults based on prior literature (Gaudreau & Peretz, 1999; Halpern & O’Connor, 2000). Our results partially supported our predictions, in that older adults did show a greater preference for the sung old lyrics when compared to the sung “new” lyrics, however, young adults showed no differences within their preference ratings. We did not find a difference in the older adult’s preference ratings for the spoken recordings, as they had similar ratings for the old spoken and new spoken recordings. Furthermore, the old sung recordings were the only condition to elicit MEE, but when both conditions were analyzed together (Old Sung + Old Spoken vs. New Sung + New Spoken), there were no difference in preference ratings for either the young adults or older adults.

Schellenberg and colleagues (2008) found that liking ratings increased linearly as a function of exposure and that their young adult sample experienced MEE as a response to number of times they were presented with the stimuli (Schellenberg, Peretz, & Vieillard, 2008). We might not have seen an overall MEE in either groups based on the number of exposures to the old stimuli. In the current paradigm, participants studied the recordings one time before making their preference ratings. An experimental design that allowed for several exposures to the stimuli, either through more trials or multiple sessions might increase the likelihood of finding the MEE effect. Alternatively, as discussed in the previous explicit memory section, this increased exposure in the young adult sample may have provided a memory boost and diminished the effect of music found in our previous studies (Finch, et al., 2019).

Conclusion and Future Directions

In conclusion, the explicit memory results differed from our prior work and contrasted with our predictions. We expected to find higher accuracy for the sung condition in both groups, however, we found that young adults showed no difference in accuracy between the conditions, while older adults were better in the spoken condition. These outcomes highlight the need for additional studies to explore the use of musical mnemonics as an aid to enhance memory in older adults. Furthermore, we predicted MEE would occur in both sample groups, yet we only found the effect in the older adult group when looking exclusively at the sung condition. Congruent to what we expected to find, both groups showed higher confidence in the correctly identified sung and spoken conditions, with older adults showing higher confidence in the sung condition regardless of the fact that they performed better in the spoken condition than the sung.

Future research using the musical mnemonics should further examine how certain factors might influence the potential for music to benefit different types of memory performance. First, there may have been an increased competition for attentional resources as the complexity of the stimulus required the binding together of the music and the lyrics. A better understanding of attention in older adults and the mechanisms involved in attentional discrepancies may help shed light on what we see occurring with older adults performing better on the spoken condition. Further studies should start by breaking-down the musical condition to include a third condition, where sung recordings are heard without accompaniment to determine if accuracy can be increased without the attentional competition of accompaniment.

Second, future research using this paradigm should control for accuracy levels by considering the number of exposures participants have to the sung and spoken stimuli, thus eliminating ceiling effects. In the current experiment, adding in a 5-minute delay for the young adults helped bring the sung and spoken accuracy levels down to what was seen in our previous studies (Finch et al., 2019), however the overall accuracy was still near ceiling. It might be necessary to add in multiple 5-10-minute delays between each encoding phase to bring the overall accuracy levels down. While, participant retention may be an issue, future studies could also add in more exposures by adding more encoding phases but have preference and accuracy tests occur in a follow-up testing session 2-3 days after initial encoding. This may increase the likelihood of finding the mere exposure effect (Bornstein, 1989) as well as keep overall accuracy levels from reaching ceiling.

Last, our current paradigm used the MoCA to assess and control for any cognitive impairment in our older adult participants. Future research might broaden the battery of neuropsychological assessments to investigate if subgroups exists within the OA participants. If subgroups based on cognitive impairments do exists, it may be easier to detect differences between accuracy and preferences that might exists for the different lyric conditions.

While we did not find what we expected using the current paradigm, the current results offer insight into how learning and memory differs between young adults and older adults. Additionally, it may provide clues as to the fundamental changes that occur to explicit and implicit memory as we age. As the average number of individuals over the age of 65 continues to increase, about 40% of those individuals will experience age related memory impairment (Small, 2002). Because of this, it is not only important but imperative to have effective and efficient memory improving strategies available. The overall goal of my research is to add to these efforts and contribute to the possible memory enhancing techniques that can be used by aging individuals. More specifically, to help add to the scientific literature with respect to the usefulness of musical mnemonics to aid in memory enhancement.

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