Simmons-Stern, Budson, and Ally (2010) were the first to demonstrate that visually presented song lyrics were better remembered by patients with Alzheimer’s disease (AD) when accompanied by those lyrics sung rather than spoken at encoding. Surprisingly, healthy older adults showed no benefit of these musical mnemonics. Healthy older adults performed significantly better in both the sung and spoken conditions than the patients with AD. Perhaps, whenever discrimination is sufficiently high, musical mnemonics do not further aid performance. To test this possibility, we introduced a 1-week delay between study and test in a paradigm otherwise identical to the one used by Simmons-Stern et al. We successfully matched the overall discrimination performance of healthy older adults to the levels of the patients with AD in the original study but still did not find a benefit of musical mnemonics. The results of this study suggest that there may be a fundamental difference in musical encoding between patients with AD—whose memory is enhanced by musical encoding—and healthy older adults—whose memory is not—even when the two groups are matched for overall performance.

Keywords: musical mnemonics, recognition memory, familiarity, Alzheimer’s disease

Popular belief holds that setting information, such as the letters of the alphabet or the U.S. states, to a musical melody can improve memory for that information. Musical mnemonics are commonly thought to aid children and adults in learning new information. When the empirical literature is examined, music has been shown to aid memory for information in a several studies (Calvert & Tart, 1993; Chazin & Neuschatz, 1990; McElhinney & Annett, 1996; Rainey & Larsen, 2002; Wallace, 1994), but to have no memory-enhancing effect in others (Kilgour, Jakobson, & Cuddy, 2000; Racette & Peretz, 2007). The potential benefits and limitations of musical mnemonics are not well understood. Further investigation of what underlies successful musical mnemonics will have important implications for their use in boosting memory performance throughout the life span as well as for potential rehabilitation techniques for patients with memory disorders, such as Alzheimer’s disease (AD).

Work in our lab has been among the first to offer empirical evidence that musical mnemonics can be used as a memory enhancer in AD patients (Simmons-Stern et al., 2010). AD patients demonstrate impairments in their ability to learn and retain new information that...
adversely impacts their daily lives; it is therefore of great interest to identify and refine successful mnemonic techniques to aid these patients. Because some aspects of memory for music may be relatively spared in AD patients, using music as a memory enhancer appeared a promising technique. To test this possibility, Simmons-Stern et al. (2010) visually presented healthy older adults and AD patients with lyrics to unfamiliar children’s songs, half of which were accompanied by a spoken recording and half by a sung recording of the song lyrics. Immediately after the study phase, participants were visually presented with the studied lyrics as well as new lyrics and asked to respond whether each lyric stimulus was old or new. AD patients were more accurate in recognizing lyrics that had been presented with a sung recording than a spoken recording at encoding. Importantly, although Simmons-Stern et al. originally predicted a mnemonic benefit of music for both AD patients and healthy older adults, the latter group showed no benefit of musical encoding on subsequent recognition memory. This unexpected result may suggest that there is a fundamental difference in musical encoding between AD patients and healthy older adults. Simmons-Stern et al. proposed several explanations for this difference, including that healthy older adults performed at a “functional ceiling” on the recognition memory task such that any potential benefit of musical encoding was negligible.

Simmons-Stern et al. (2010) suggested that the AD patients may have benefited from musical encoding because music activates a number of brain regions, some of which are relatively spared in AD than the medial temporal lobe regions typically involved in recognition memory (Thompson et al., 2003). For example, the sung condition might have led to a more distributed encoding than the spoken condition owing to added recruitment of the many brain regions involved in processing music, including basal ganglia and cerebellum, which are relatively spared in AD (Grahn, 2009; Koelsch, 2011; Levitin & Tirovolas, 2009; Limb, 2006; Peretz et al., 2009). Additionally, the sung condition may provide more cues at retrieval in a manner similar to the dual coding hypothesis proposed for pictures (Paivio, 1971). Healthy older adults, who show relatively intact episodic memory processing, performed significantly better in both the sung and spoken conditions than AD patients. Perhaps, whenever the level of discrimination is sufficiently high, the more distributed nature of musical encoding is simply not necessary to aid performance. Potentially, if the performance of healthy older adults is lowered to match that of AD patients, healthy older adults will show a similar benefit of musical mnemonics.

In the current study, we investigated this possibility by introducing a 1-week delay between the study and test phases to match overall recognition performance between healthy older adults and AD patients. We chose to use a delay rather than other methods of matching performance (e.g., increased number of stimuli) to keep the procedure as similar as possible to Simmons-Stern et al. (2010). Additionally, the method of matching performance between healthy controls and patients has been shown to have a demonstrable effect on results. The use of a delay has been suggested to not only match performance, but to also result in controls relying on memorial processes more similar to patients (Deason, Hussey, Ally, & Budson, 2012; Giovanello & Verfaellie, 2000). If a study-test delay reduced healthy older adults’ overall recognition performance to the same level as the AD patients in Simmons-Stern et al., we predicted that the healthy older adults would show a similar benefit of musical encoding over spoken encoding on subsequent recognition memory.

**Method**

**Participants**

Twelve healthy older adults (five male) were recruited for this study from online and community postings in the Boston area. Participants were screened for clinically significant depression,
alcohol or drug use, stroke, traumatic brain injury, or other neuropsychological disorder. All participants were native English speakers and had normal or corrected to normal vision and hearing. The study was approved by human studies committees at VA Boston Health care System and Boston University, both in Boston, MA. Written informed consents were obtained from all participants. Participants were paid $10/hour for participating.

Table 1 presents demographic and neuropsychological data for the participants and also compares them with the participants from Simmons-Stern et al. (2010). Importantly, there were no significant differences in these measures between the healthy older adults in the current study and the groups used in Simmons-Stern et al.

**Materials**

The stimuli consisted of four-line excerpts of 80 obscure children's songs used in Simmons-Stern et al. (2010). The children's songs were chosen as stimuli because the songs had simple, unrepeated lyrics, a perfect tail rhyme section, and had been previously rated as unfamiliar by a separate group of healthy older adults. These excerpts were presented visually in addition to being presented auditorily either as a sung or spoken recording. The 80 songs were divided into four lists of 20 songs equated on number of words (mean \( M = 22.5 \), standard deviation \( SD = 4.83 \) ), song recording length (\( M = 26.2 \) sec, \( SD = 7.08 \) ), spoken recording length (\( M = 27.1 \) sec, \( SD = 7.79 \) ), Flesch-Kincaid Grade Level, and text readability. Assignment of lists to experimental conditions was counterbalanced across participants. The stimuli were completely counterbalanced so that each song appeared in each condition (spoken, sung, new) across participants. The lists and counterbalancing used were identical to those used in Simmons-Stern et al. (2010) to minimize differences between the two experiments.

**Procedure**

The current experiment used a procedure identical to that used in Simmons-Stern et al. (2010) but with a 1-week delay between the study and test phases. In the first session, participants completed only the study phase. First, participants were instructed to try to remember the lyrics for a later recognition test. Participants then went through a short practice to familiarize them with the procedure. During the study phase, participants were visually presented with the lyrics of 40 four-line songs. Each set of lyrics was accompanied by two consecutive repetitions of either a sung recording (20 sets of lyrics) or a spoken recording (20 different sets of lyrics). Sung and spoken recordings were randomly intermixed and the auditory stimuli were presented using headphones set at a comfortable volume. After participants listened to two repetitions of the auditory stimuli, they were asked if the lyrics were familiar to them (i.e., if they had heard the song before the experiment). Lyrics rated as familiar by the participant were excluded from analyses as we were only interested in responses to novel stimuli.\(^1\)

After a 1-week delay, participants were presented with 80 sets of lyrics (40 old, 40 new) in the test phase. Participants were instructed to respond "old" if the lyrics had been presented before or "new" if the lyrics had not been presented previously. The song lyrics remained on the screen until participants responded, but no audio recording was played during the test phase.

<table>
<thead>
<tr>
<th>OC-delay</th>
<th>OC-no delay</th>
<th>AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sung hit rate</td>
<td>0.55 (0.15)</td>
<td>0.80 (0.09)</td>
</tr>
<tr>
<td>Spoken hit rate</td>
<td>0.63 (0.20)</td>
<td>0.84 (0.10)</td>
</tr>
<tr>
<td>Overall hit rate</td>
<td>0.59 (0.15)</td>
<td>0.82 (0.09)</td>
</tr>
<tr>
<td>False alarm rate</td>
<td>0.17 (0.16)</td>
<td>0.06 (0.09)</td>
</tr>
</tbody>
</table>

**Results**

To examine the difference in memory performance in healthy older adults between the sung and spoken conditions after a 1-week delay, we calculated \( Pr (\% \) hits – \% false alarms; Snodgrass & Corwin, 1988; see Table 2). A repeated-measures analysis of variance (ANOVA) was conducted using a within-subjects factor of condition (sung vs. spoken) examining memory performance (\( Pr \)). Healthy older adults demonstrated no main effect of condition (\( F(1, 11) = 2.56, p = .13, \eta^2 = .19 \) ) despite a slight numerical advantage for the spoken condition (spoken \( Pr = 0.45 \); sung \( Pr = 0.38 \)).

To further explore the differences between healthy older adults (OC) and AD patients, we performed analyses using data from Simmons-Stern et al. (2010). A repeated-measures ANOVA was conducted using a within-subjects factor of condition (sung vs. spoken) and a between-subjects factor of group (OC-delay, OC-no delay, AD) examining memory performance (\( Pr \); see Figure 1). There was no main effect of condition although there was a main effect of group (\( F(2, 33) = 20.92, p < .001, \eta^2 = .559 \) ). The healthy older adults in Simmons-Stern et al. with no delay performed better overall (\( Pr = 0.76 \) ) than the healthy older adults in the current experiment after a 1-week delay (\( Pr = 0.42; t(22) = 5.81, p < .001 \) ). There was also a significant interaction between condition and group (\( F(2, 33) = 8.68, p < .01, \eta^2 = .35 \) ). To further examine differences between the OC-delay and the AD groups, a repeated-measures ANOVA was conducted using a within-subjects factor of condition (sung vs. spoken) and a between-subjects factor of group (OC-delay, AD) examining memory performance. There was no difference in overall recognition performance between the OC-delay group (\( Pr = .42 \) ) and the AD patients after no delay (\( Pr = 0.34; F(1, 22) = 1.12, p = .30, \eta^2 = .05 \) ). There was no main effect of sung versus spoken condition (\( F(1, 22) < 1, p = .40, \eta^2 = .03 \) ). However, there was a significant interaction between group and condition (\( F(1, 22) = 12.25, p < .01, \eta^2 = .36 \) ). Follow-up tests showed that although there was no significant difference in recognition between the sung and spoken conditions for the OC-delay group, \( t(11) = 1.60, p = .14 \), the AD patients showed a greater \( Pr \) for the sung versus the spoken condition, \( t(11) = 3.87, p < .01 \), as reported in Simmons-Stern et al. Additionally, while there was no significant difference

\(^1\) To match exactly how the data were processed in the Simmons-Stern et al. study, we also discarded one song for all participants that had been rated familiar by many older control participants in the Simmons-Stern et al. study. Separate analyses were performed for all experimental data both including and excluding the lyrics rated familiar; identical results were found. As in Simmons-Stern et al., the data and analyses presented are without this one song.
compared with the AD patients (Ally, Gold, & Budson, 2009; Westerberg et al., 2006). If musical encoding recollection (Ally, Gold, & Budson, 2009; Ally, McKeever, Waring, & Budson, 2009; Westerberg et al., 2006) is entirely spared in patients with AD, it is better preserved than recollection. While familiarity is not without a study-test delay (Balota, Burgess, Cortese, & Adams, 2002; Albouy, Daffner, Desikan, & Schacter, 2000; Smith & Knight, 2002; Wolk et al., 2011a, b). Thus, the healthy older adults may have been relying more strongly on familiarity than recollection, similar to AD patients. If that were the case, our results would then suggest that enhancement of familiarity alone does not appear to be the underlying cause of successful musical mnemonics in AD patients. Further research needs to be done to investigate the underlying mechanisms of musical mnemonics as well as the possible benefits and limitations of use. We examined memory for the exact studied song lyrics; perhaps testing for the general idea, or gist, of the song lyrics may result in a benefit of musical mnemonics for both AD patients and healthy older adults. Another possibility is that positive affect elicited by the songs enhanced encoding in AD patients by helping to focus attention on the particular lyrics. Older adults may not need this extra focus of attention in the encoding phase and thus not have received any extra benefit of musical encoding. Follow-up experiments could examine whether a divided-attention task at encoding for the older adults might lead them to show a benefit for musical mnemonics. In our current paradigm, sung and spoken conditions were intermixed at encoding, which might have dampened any overall effect of general music-based attention enhancement. A blocked-design study would allow for better examination of memory enhancement owing to slow onset mechanisms, such as attention and arousal. Lastly, it will be important to examine whether music can improve memory for new information relevant to the daily lives of older adults and AD patients. Music is important to the quality of daily life for many older adults regardless of their mental status (Cohen, Bailey, & Nilsson, 2002), and thus, musical mnemonics are appealing to healthy older adults as well as AD patients. Future experiments should aim to determine the conditions and populations that benefit most from the use of music as a memory enhancer.

Discussion

Our introduction of a 1-week delay was successful in reducing the overall performance of the healthy older adults to a level matched with that of AD patients in Simmons-Stern et al. (2010). Despite this matched overall performance, however, healthy older adults showed no significant difference in recognition memory performance for lyrics that had been accompanied by a sung versus a spoken recording during the encoding phase. Moreover, healthy older adult performance in the present experiment trended in the opposite direction from that of the AD patients, leading to a significant interaction and a trend toward better performance by the healthy older adults compared with the AD patients in the spoken condition. These results suggest that there may be a fundamental difference in musical encoding between AD patients—whose memory is enhanced by musical encoding—and healthy older adults—whose memory is not—even when the two groups are matched for performance.

The 1-week delay between the study and test phases not only allowed us to match patients and older adults on discrimination, but to potentially match memorial processes used as well. Dual process theory hypothesizes that recollection and familiarity are two independent processes that contribute to accurate recognition decisions (Yonelinas, 2002). Recollection is recall of an item that brings to mind specific details/context. Familiarity is a more general sense of having encountered an item before without recall of specific context. Recollection is severely impaired in AD patients; they are generally forced to rely mainly on familiarity—even without a study-test delay (Balota, Burgess, Cortese, & Adams, 2002; Budson, Daffner, Desikan, & Schacter, 2000; Smith & Knight, 2002; Wolk et al., 2011a, b). While familiarity is not entirely spared in patients with AD, it is better preserved than recollection (Ally, Gold, & Budson, 2009; Ally, McKeever, Waring, & Budson, 2009; Westerberg et al., 2006). If musical encoding had preferentially enhanced familiarity and not recollection, then this preferential enhancement could explain why the benefit of music was found only in AD patients in Simmons-Stern et al. (2010). Because AD patients are impaired in recollection, they presumably relied primarily on familiarity to make their recognition decisions, whereas the healthy older adults likely relied on both recollection and familiarity.

Prior work has suggested that introducing a study-test delay degrades recollection more than familiarity (Deason et al., 2012; Gardiner & Java, 1991; Giovanello & Verfaellie, 2001; Hockley & Consoli, 1999; Wolk et al., 2006; Yonelinas, 2002). Thus, after the delay, healthy older adults may have been relying more strongly on familiarity than recollection, similar to AD patients. If that were the case, our results would then suggest that enhancement of familiarity alone does not appear to be the underlying cause of successful musical mnemonics in AD patients. We therefore need to look to other causes to explain the benefit of musical mnemonics in AD patients.

Further research needs to be done to investigate the underlying mechanisms of musical mnemonics as well as the possible benefits and limitations of use. We examined memory for the exact studied song lyrics; perhaps testing for the general idea, or gist, of the song lyrics may result in a benefit of musical mnemonics for both AD patients and healthy older adults. Another possibility is that positive affect elicited by the songs enhanced encoding in AD patients by helping to focus attention on the particular lyrics. Older adults may not need this extra focus of attention in the encoding phase and thus not have received any extra benefit of musical encoding. Follow-up experiments could examine whether a divided-attention task at encoding for the older adults might lead them to show a benefit for musical mnemonics. In our current paradigm, sung and spoken conditions were intermixed at encoding, which might have dampened any overall effect of general music-based attention enhancement. A blocked-design study would allow for better examination of memory enhancement owing to slow onset mechanisms, such as attention and arousal. Lastly, it will be important to examine whether music can improve memory for new information relevant to the daily lives of older adults and AD patients. Music is important to the quality of daily life for many older adults regardless of their mental status (Cohen, Bailey, & Nilsson, 2002), and thus, musical mnemonics are appealing to healthy older adults as well as AD patients. Future experiments should aim to determine the conditions and populations that benefit most from the use of music as a memory enhancer.

References


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