Music as an Aid to Learn New Verbal Information in Alzheimer's Disease

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THE GOAL OF THIS STUDY IS TO ASSESS WHETHER NEW LYRICS ARE better learned and memorized when presented in a spoken or sung form. In normal young adults, mixed results have been reported, with studies showing a positive, a negative, or a null effect of singing on verbal recall. Several factors can account for this limited aid of music. First, the familiarity of the melody might play a role. Second, successive learning sessions and long-term retention intervals may be necessary. These two factors are considered here in a case study of a participant who suffers from mild Alzheimer's disease. As expected, initial learning of new lyrics showed better performance for the spoken condition over the sung version unless the lyrics are learned on a familiar melody. After repeated learning episodes, learning sung lyrics – even on an unfamiliar melody – led to better retention of words. Thus, music may provide a more robust aid for consolidation in memory than spoken lyrics alone. The therapeutic implications of these results are discussed.

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THE NOTION THAT MUSIC COULD SERVE AS A MNEMONIC technique is a long-held belief. For example, songs would have aided minstrels to transmit historical events or stories (Calvert & Tart, 1993; Rubin, 1995). This belief is still influential today, for example in the use of musical jingles for advertisement. In education, a song is sometimes used to help children learn the alphabet. Other examples consist of learning the laws of physics through karaoke (Dickson & Grant, 2003), or learning English as a second language via songs (Medina, 1993). In the present article, we will try to better understand how music can help verbal memory, by reviewing the experimental literature. These studies were largely conducted on normal subjects. Next, we will address this question in a case study with an Alzheimer's disease participant.

The potential effect of music as a mnemonic technique for verbal material can be explained by different principles. For example, syntactic processes for music and language seem to share an important part of the same anatomical and functional cerebral resources (Maess, Koelsch, Gunter, & Friederici, 2001; Patel, 2003). This brain overlap or proximity between music and language networks might help memory for songs by enhancing connections between lyrics and melody. Another possible relation between music and verbal memory is emotion. Music is a privileged means for expressing emotions (see Juslin & Västfjäll, 2008, for a review), which in turn plays a critical role in memorization (e.g., Nairne, Thompson, & Pandeirada, 2007; Sitoh & Tien, 1997). This link between emotion and memory may also serve verbal memory. It is well-known that words with an emotional content are better memorized than neutral ones in a list learning task (Kensinger & Corkin, 2003). Thus, music may enhance memory via emotional mechanisms (Eschrich, Münte, & Altenmüller, 2008; Jäncke, 2008). Finally, emotion could also influence memory through a general *arousing* effect. Indeed, exposure to stimulating music increases cognitive functioning (see Latendresse, Larivée, & Miranda, 2006, for a review of 26 studies). This effect is important in dementia, because it may compensate for apathy (Holmes, Knights, Dean, Hodkinson, & Hopkins, 2006) and increase attention and motivation, thereby improving learning and memory capacities.

The surface characteristics of a melody may also aid the learning of lyrics by providing cues and constraints (Wallace, 1994). The rhythm, for example, can give cues for the lyrics structure (such as the number of syllables

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per line) and limit the possible choices among the words that can be set to the melody. Moreover, when the melody is properly set to the lyrics (Gingold & Abravanel, 1987; Wallace, 1994), the melodic structure affords the formation of chunks. Chunks facilitate both encoding and retrieval, and songs tend to be organized in chunks in long term memory (Dowling, 1973). Indeed, McElhinney and Annett (1996) showed that even when participants recalled more chunks from spoken lyrics than from sung ones, they recalled more words per chunk in the sung condition.

However, music does not systematically facilitate verbal memory. When the learning of spoken new verbal material (such as tests or word lists) is compared with the learning of sung new verbal material, mixed results are observed. Some studies showed that participants recalled as much sung as spoken information (Gingold & Abravanel, 1987; Jellison & Miller, 1982; Kilgour, Jakobson, & Cuddy, 2000; Rainey & Larsen, 2002; Wolfe & Hom, 1993). Some even reported worse performance for sung than spoken material (Calvert & Billingsley, 1998; Jellison & Miller, 1982; Racette & Peretz, 2007). Yet, others showed an advantage of sung over spoken presentation (Calvert & Tart, 1993; Chazin & Neuschatz, 1990; Kilgour et al., 2000; McElhinney & Annett, 1996; Rainey & Larsen, 2002; Wallace, 1994; Wolfe & Hom, 1993).

An important factor to consider is that performance seems related to melodic characteristics. Wallace (1994) has shown that the melody associated with the lyrics to be memorized has to be simple, symmetric, and repeated across the successive lines of the song. A second factor is that lyrics learning is easier when associated with a highly familiar melody as compared to an unfamiliar melody (Korenman & Peynircioglu, 2004; Purnell-Webb & Speelman, 2008; Wolfe & Hom, 1993, in 5-years-old children). Interestingly, Purnell-Webb and Speelman (2008) investigated an intermediate level of familiarity, where participants were presented with the melody alone before learning it with the lyrics. Yet, performance was not better when compared to the recall of the same lyrics coupled with an unfamiliar melody. However, the familiarization with the melody consisted of only six passive exposures. Moreover, the melody was presented in a different form (i.e., it was played on the piano) than when learning the sung lyrics. This change in format may interfere with melody recognition (Poulin-Charronnat et al., 2004).

Different theoretical frameworks have been proposed to account for the memorization of melody and lyrics in songs. Originally, Serafine and collaborators (Serafine, Crowder, & Repp, 1984; Serafine, Davidson, Crowder, & Repp, 1986) proposed that lyrics and melody are integrated in a unitary memory representation. This implies that the two components of a song are not dissociable. Yet, in a following study, the same authors modified their position slightly, identifying different degrees of integration of the lyrics and the melody of a song (Crowder, Serafine, & Repp, 1990). A recent neuroimaging study (Sammler et al., 2010) was partly in line with the integration hypothesis, highlighting integration of these two components for phonemic processing and for vocal planning of singing. However, this study also showed that lyrics seem to be processed independently at a structural and semantic level. Moreover, neuropsychological dissociations have been reported, whereby only one of these two components could be lost after brain damage. For example, amusic participants can recognize highly familiar songs based solely on their lyrics, not on their melody (Peretz, 1996). Therefore, lyrics and melody are separable even if these are tightly associated (Hébert & Peretz, 2001; Peretz, Gagnon, Hébert, & Macoir, 2004; Peretz, Radeau, & Arguin, 2004).

If lyrics and melody of songs are sustained by separate memory representations, learning a song represents a dual task for the participant who has to learn both components, not just one (Racette & Peretz, 2007). This model may explain why learning a sung excerpt may be more difficult to learn than lyrics alone, at least in the first steps of learning. It is also consistent with the observation (Wallace, 1994) that performance is improved when the melody is simple, and thus easy to memorize. The dual memory account is also consistent with the finding of superior performance for sung conditions when the melody is already familiar (Korenman & Peynircioglu, 2004; Purnell-Webb & Speelman, 2008; Wolfe & Hom, 1993). Similarly, the fact that singing is generally slower than speaking may facilitate the learning of the two components (Kilgour et al., 2000). In all these cases, the learning of both lyrics and melody is helped when the memory load associated with the musical component is decreased.

Although it can be more demanding to learn both lyrics and melody of songs than either component alone during the encoding stage, the learning of both components creates an associative link between the two items to be memorized, leading to a deeper encoding that may facilitate storage and retrieval in the long-term (e.g., Paivio, 1967; Paivio, Clark, & Khan, 1988). Indeed, McElhinney and Annett (1996) showed that even though sung lyrics were initially remembered equally well as spoken lyrics, performance improved in the sung condition at a greater rate. After three presentations, sung lyrics were, on average, remembered twice as well as the spoken ones. Similarly, Rainey and Larsen (2002) observed no initial advantage of a sung over a spoken list of words in the first learning session, but found that participants required fewer trials to relearn the sung list

as compared to the spoken list one week later. Calvert and Tart (1993) also reported better short and long-term memorization of the preamble of the Constitution when sung than when spoken when participants were repeatedly exposed to the material, while they observed no difference when the participants were exposed to the material only once. More evidence comes from a case study with an aphasic patient (Wilson, Parsons, & Reutens, 2006). The patient had to learn 20 sentences that were either rhythmically spoken or rhythmically sung. One week after training, both of these conditions led to better retention than for untrained sentences; however, after five weeks, the sung condition led to the best recall performance. Taken together, these observations suggest a more efficient consolidation process for sung conditions, which may form a deeper/associative encoding.

While the question of music as a mnemonic device may have clinical relevance for memory rehabilitation, only two studies have as yet addressed this topic with participants with memory impairments. In the first study (Prickett & Moore, 1991), ten Alzheimer's disease patients were equally poor at learning unfamiliar sung lyrics and unfamiliar spoken ones. Yet, what is interesting in this study is that these patients relearned a life-long familiar song better than a life-long familiar spoken text (i.e., a prayer). These results are consistent with the normal literature reviewed previously. However, there were some methodological shortcomings in this early study. Notably, stimuli complexity across conditions was not controlled. Moreover, the degree of severity of these patients was not reported. The other and more recent clinical study (Simmons-Stern, Budson, & Ally, 2010) showed that mild Alzheimer's participants better memorized short verbal excerpts when they were sung rather than spoken. However, the task differed from previous studies; a recognition task (old/new judgment) instead of a recall task was used. Nevertheless, these two prior studies of Alzheimer's participants are very encouraging in showing that music can aid verbal memory.

The present study further illustrates how music can aid the recall of new lyrics in one mild Alzheimer's disease participant, comparing the effects of melody familiarity and learning episodes on recall. The initial phase consists of comparing the memorization of four new lyrics excerpts in four conditions: (1) spoken, (2) sung on a non-familiar (NF) melody, (3) sung on a recently learned (low familiar, LF) melody, and (4) sung on a life-long and highly familiar (HF) melody. The lyrics were learned by speaking/singing in unison with a model as this learning procedure was found to be adequate for aphasic participants in an earlier study using the same material (Racette, Bard, & Peretz, 2006). For the three sung excerpts, we predicted that performance would increase with melody familiarity, and that the unfamiliar sung lyrics would lead to worse recall than the spoken ones. The second phase of the study consisted of relearning the spoken and unfamiliar sung lyrics. We predicted that the sung lyrics would lead to better memorization than the spoken ones over time.

Method

PARTICIPANT

JL was a 68-year-old right-handed woman, with a low level of education (7 years). She stopped school when she was 14-year-old and then became a nun for a few years. She had to stop for medical reasons when she was 20, and then worked as a cleaning lady in a hospital and in a church. Since her retirement, she has acted as a volunteer in a health centre every morning.

In October 2004, she was referred to the Institut Universitaire de Gériatrie de Montréal for memory difficulties, and after an evaluation, it was determined that she met the criteria for mild cognitive impairment. In March 2009, her cognitive impairment was classified as Alzheimer's disease, according to NINCDS-ADRDA criteria. When we saw her 11 months later, she presented with mild dementia, as determined by a MMSE score of 25/30. Complementary neuropsychological assessments revealed episodic verbal memory impairment. Her scores in attention, working memory, verbal comprehension, and her auditory capacities were sufficiently high to perform the experimental tasks (see Table 1 for details). She had no psychiatric or neurologic antecedents. She was not a musician but she liked music. Her musical abilities were tested with the reduced child version of the Montreal Battery of Evaluation of Amusia (Peretz et al., 2012). In this test, JL had to discriminate a note change in melodies, which could either violate the key, the interval size or the contour, and the rhythm. Her scores (Table 1) did not differ from three age-matched controls. Moreover, she was normal at recognizing and classifying basic emotions (fear, sadness, and happiness; Table 1) in 2-s excerpts taken from a standardized set (Vieillard et al., 2008). JL was also able to judge whether an instrumental melody was familiar or not (Samson, Baird, Moussard, & Clément, 2012), but she was unable to recognize these same melodies in a yes/no memory recognition task, even after three presentations (Samson et al., 2012). Thus, she showed impaired episodic memory for melodies, when compared with three controls (Table 1).

TABLE 1. Neuropsychological, Auditory, and Musical Scores Obtained by JL.

Function	Test	Score	Observations
General cognitive functioning	MMSE (Folstein, Folstein, & McHugh, 1975)	25/30	Mild dementia stage
Verbal memory	15 words of Rey (Rey, 1970)	Number of words recalled for the five trials: 2 / 8 / 8 / 7 / 7; and for the recognition test: 12	Total of words recalled: percentiles 25-50; Recognition: percentile 50
Working memory	Digit span	Forward = 5; backward = 5	Normal
Executive functions	Stroop (Regard, 1981)	Time (s) / Errors for colours = 14 / 0; words = 16 / 0; and interference = 26 / 2	Time: Normal Errors: -2.41 *SD* for interference condition
Sustained attention	TEA (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1994): elevator counting subtest	7/7	Normal
Verbal comprehension	Token test (De Renzi & Vignolo, 1962)	39/44	Low average
Mood	Geriatric Depression Scale (Yesavage et al., 1983)	1/30	Normal
Auditory capabilities	Repetition of 24 spoken and sung sentences from the experimental material	23/24	Normal
Musical experience	Questionnaire (Ehrlé, 1998)	4/27	Non musician
Musical abilities	Identification test for amusia (Peretz et al., 2012)	Scale = 18/20; Contour/interval = 14/20; Rhythm: 16/20	Normal
Recognition of musical emotion	Recognition of happiness, sadness, and fear in short excerpts (Vieillard et al., 2008)	Happiness = 81% Sadness = 73% Fear = 56%	Normal (Chance level = 25%)
Memory for music	Familiarity judgment and episodic recognition of familiar and unfamiliar melodies (Samson et al., 2012)	Familiarity judgment: Hits-FA = 8/8 Episodic memory (after 3 presentations): Hits-FA: familiar melodies 4/8; unfamiliar melodies = 2 /8	Familiarity judgment: Normal Episodic memory: Impaired

MATERIAL AND PROCEDURE

Learning phase. Materials and procedures were adapted from prior studies conducted by Racette and collaborators (Racette et al., 2006; Racette & Peretz, 2007). Four unfamiliar songs, from the repertoire of Claude Gauthier, a popular French-Canadian folk-singer and songwriter, were selected. These songs were deemed "good songs" in a pilot study in which participants judged their musicality, simplicity, and potential to be a hit. The four lyrics had equal linguistic familiarity, based on a French lexical database (New, Pallier, Ferrand, & Matos, 2001). Each excerpt contained eight lines, with few word or melodic line repetitions. Each line contained an average of six words and eight notes, with one-to-one mapping between syllables and tones. Lines respected the grouping preference rules proposed by Lerdahl and Jackendoff (1983), and the alignment of the lyrics and of the melody rhythm conformed to the rules used for French songs (Dell, 1989). As for musical structure, the songs had a stable, standard metre and were in major mode.

The lyrics of the four excerpts were recorded by a female singer and randomly assigned in one of the following conditions: one was spoken (recited with natural intonation and speed), two were sung on their original, unfamiliar melodies (i.e., for the non-familiar/NF and low-familiar/LF conditions), and one was sung on the familiar melody of Beethoven's *Ode to Joy* (see Figure 1 for an example of this condition). In order to keep the one-to-one mapping between syllables and tones, the lyrics

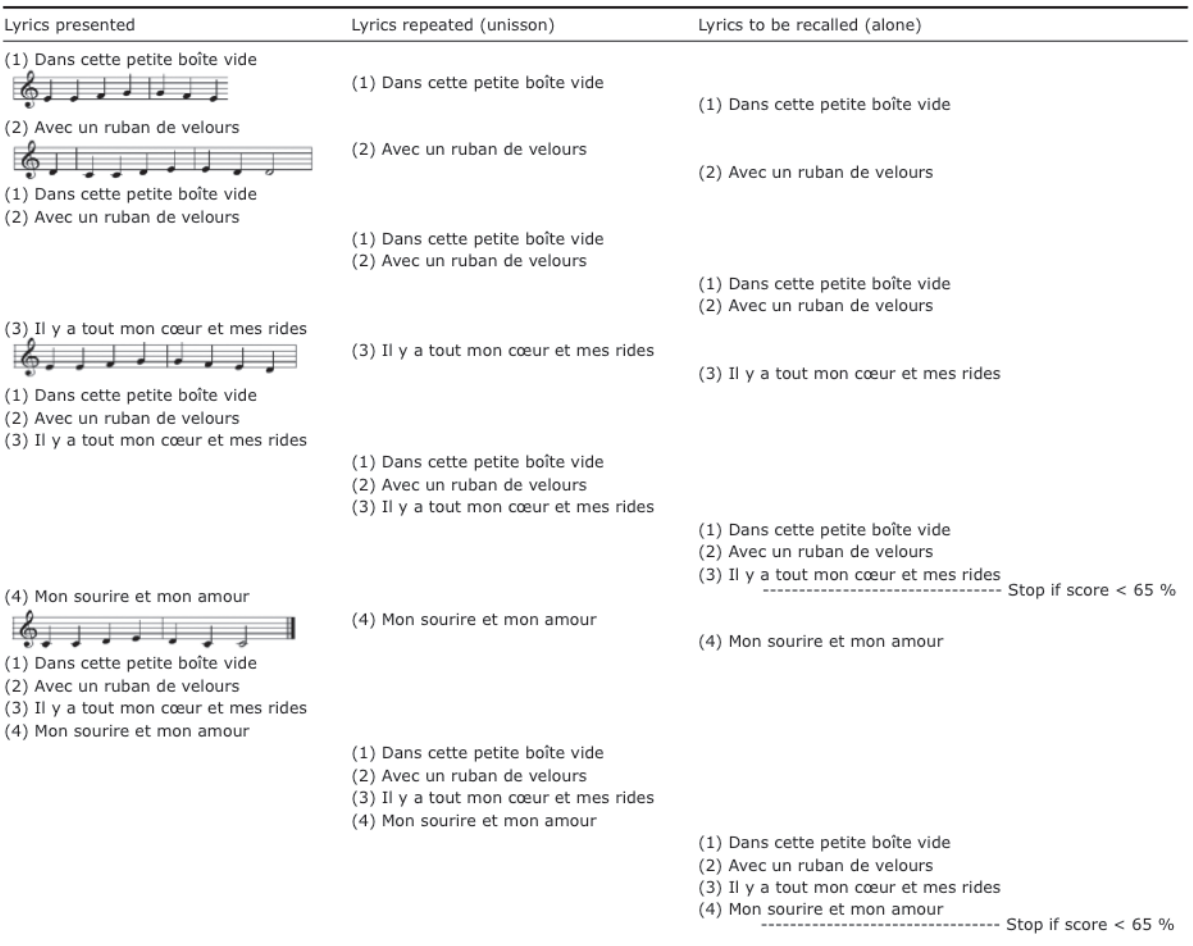

FIGURE 1. Illustration of the adaptive learning procedure for four lines (after listening to the entire excerpt for familiarization). For each trial, there were three steps: listening, repetition in unison with the model, and repetition alone (recall). The dotted line shows a possible stop of the task, if the participant recalled less than 65% of the words presented. This excerpt corresponds to the familiar melody condition with Beethoven's *Ode* to *Joy*.

were slightly modified. The sung versions were recorded a capella – without instrumental accompaniment. The duration (in s) of the four eight-line lyrics excerpts was 21.5 s (0.33 s per syllable, on average) for the spoken lyrics, 33.5 s (0.52 s per syllable) and 28.5 s (0.41 s per syllable) for the two sung lyrics coupled with their original melodies, and 33.6 s (0.51 s per syllable) for the lyrics sung on the familiar *Ode to Joy*. The duration of the spoken version was shorter than the sung ones, in line with natural speech, in order to keep stimuli as ecological as possible.

Because there is a high variability in the number of lines that a participant is able to learn, even in normal subjects (Racette & Peretz, 2007), we used here an adaptive procedure. This procedure is represented in Figure 1. The participant first listened to the whole excerpt once in order to familiarize herself with it. Afterwards, the first line was presented. That same line was presented a second time, and the participant had to produce it in unison with the model. Then, she was asked to produce the line alone and to try to memorize it. The second line was presented according to the same procedure: listened to, repeated at unison, and repeated alone. Then the two first lines were presented together, then the third, then the three first lines together, the fourth, and so on. A new line was added if the participant recalled at least 65% of the words presented in the previous recall trial (repetition alone), with a minimum of three lines learned for each excerpt. After the three first lines, if fewer than 65% of words were recalled, the procedure was stopped. This procedure put the emphasis on encoding and repetition in order to make the task accessible to a participant with mild Alzheimer's disease. Finally, a delayed recall after a 10-min delay measured forgetting rate. The task was to recall the exact words and, if she did not remember them, to report whatever came to mind. The score calculated was

the percentage of words correctly recalled out of the presented words for each trial where the participant had several lines to recall (i.e., we did not include the trial where only one line had to be repeated).

Four lyrics excerpts were learned in four conditions: spoken, sung on a non-familiar melody (NF), sung on an unfamiliar melody previously learned (i.e., low familiarity, LF), and sung on a familiar melody (Ode to Joy, i.e., high familiarity, HF). For the LF condition, the participant was exposed to the melody several times during a couple of weeks before testing lyrics learning, with a recorded version sung on "la" by the same singer. The number of exposure was not strictly controlled because the participant had to listen to a CD's recording at home and on her own several times per week, with verbal and written reminders; the experimenter finally ensured that the participant was able to sing it at unison with the recorder before learning the lyrics. When learning sung lyrics, JL was told that recall of words was more important than the melody. The recall trials were preferentially made in the same form as presentation (either spoken or sung). However, if she felt more comfortable speaking than singing for sung lyrics recall, it was also accepted. Note that the experimenter could give the participant the first syllable of each line in order to initiate recall.

The four lyrics excerpts were learned in separate sessions, and were part of a larger evaluation protocol, involving 12 sessions of testing with the participant – generally two per week. They were presented in an arbitrary order, as follow: sung NF, sung HF, spoken and sung LF. The sessions took place at the home of the participant. Stimuli were presented through a loudspeaker, and the entire session was recorded and filmed.

Relearning phase. The two excerpts that were learned previously in a spoken and sung version (on a non-familiar melody-NF) were reused here. These were relearned five more times, in 10 supplementary sessions. The first eight sessions occurred twice a week, and the participant learned alternatively either the spoken or sung lyrics (for example, the spoken excerpt was learned each Monday, and the sung one each Thursday). The last two sessions occurred one month later (week 9). The same adaptive learning procedure was used as in the initial learning episode, except that this time, the experimenter made JL learn for each excerpt at least the same number of lines as she did in the prior session. Each of these 10 sessions contained also a delayed recall after 10 minutes.

Results

LEARNING PHASE

We first compared the scores obtained in immediate recall for the four conditions. JL reached the criterion of 65% of correct word recall after the first three lines of the unfamiliar sung condition (NF), and the first four lines in the three other conditions (spoken, sung LF, and sung HF). To allow comparisons across condition, we examined the first three lines of each excerpt. We calculated the percentage of words recalled (out of the words presented) over lines 1 and 2, and lines 1, 2, and 3. The results are presented in Figure 2. JL's best performance was obtained with the sung LF version (with 30 words recalled) and her worst performance was observed with the sung NF version (11 words recalled; the effect of condition was significant, Pearson's $\chi^2(3) = 29.79$, $p < .0001$). Contrast comparisons revealed that recall for the sung NF condition was significantly lower than the three other conditions, which did not differ from each other.

JL made only two intrusion errors in the data recall: one semantically related intrusion for the sung LF condition, and one phonological intrusion for the sung NF one.

JL was free to recall the sung excerpts in singing or speaking. We observed that she spoke most of the time, except in the LF condition, with 67% of sung words (while she did so only 24% and 30% for the sung words in the NF and HF conditions, respectively). Yet, she did know the familiar *Ode to Joy* melody sufficiently well for singing it along with the experimenter before learning it with novel lyrics.

JL could not remember any word ten minutes after learning, except for the sung LF condition (unfamiliar melody previously learned), where she recalled four words (out of the 20 learned words in the first three lines).

RELEARNING PHASE

In order to examine progress over learning sessions, we calculated the number of words recalled at each trial, and

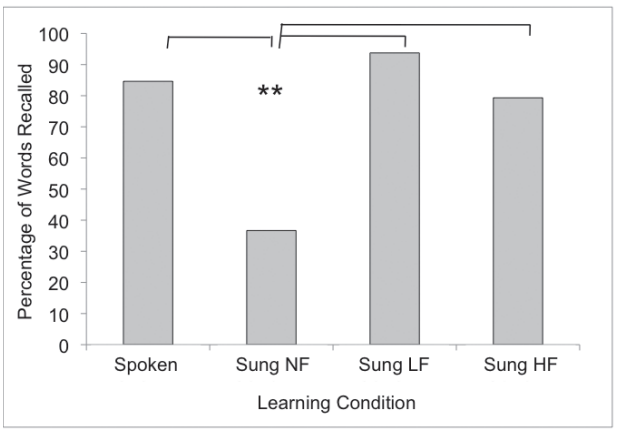

FIGURE 2. Learning scores of JL in the four conditions. Percentage of words correctly recalled (out of total words presented). Asterisks indicate a significant difference between conditions; ** $p < .01$.

calculated the ratio of the words correctly learned out of the total of words in the entire excerpt[1] (i.e., 46 words for each excerpt). JL's scores are presented in Figure 3. A log-linear analysis (Session x Condition) revealed a main effect of session, $G^2(4) = 57.70$, $p < .0001$, indicating that performance increased over time. There was also a marginal effect of condition, $G^2(1) = 3.34$, $p = .06$, suggesting that the spoken lyrics tended to be better memorized than the sung ones. More interestingly, there was an interaction between session and condition, $G^2(13) = 83.98$, $p < .0001$, suggesting different learning curves for the spoken and sung material.

Lyrics recall was not different between the spoken and sung version at week 1 and 3. The spoken condition led to better performance at week 2 and 4, $\chi^2(1) = 3.48$, $p = .06$, and $\chi^2(1) = 17.36$, $p < .0001$, respectively. In contrast, at week 9, the sung condition was better performed than the spoken one, $\chi^2(1) = 4.83$, $p < .05$. A simple logistic regression showed a learning slope – across the five relearning sessions – that was steeper for the sung condition (slope = .17, $R^2 = .90$) than for the spoken one (slope = .08, $R^2 = .29$).

[1] This ratio is based on the total number of words to be learned in the excerpt, and not based on the number of words presented, in order to leave room for progress over sessions.

When learning sung lyrics, JL recalled again more words while speaking than singing (only 31% of the words recalled were sung over the five relearning episodes), and this tendency did not change across sessions, while the melody probably became more and more familiar.

Across the relearning sessions, JL made four semantically related intrusion errors, six phonological ones (for example, "profeïque" for "prosaïque"), and three others (neither semantically nor phonologically related) in the sung condition, and one semantically related and five others in the spoken condition.

Delayed recall scores showed a clear superiority effect of the sung over the spoken lyrics after initial relearning. The proportion of words recalled relative to the number of words learned 10 min earlier in each session is presented in Figure 4. This was supported by the log-linear analysis, which showed a main effect of session, $G^2(4) = 52.68$, $p < .0001$, and a main effect of condition, $G^2(1) = 13.22$, $p < .001$. The interaction between session and condition, $G^2(13) = 74.84$, $p < .0001$, reflected the fact that at week 1 and 2, delayed recall did not differ between the spoken and sung material. At week 3 and thereafter, the sung superiority effect reached significance (by Fisher exact probability one-tailed test). In the last session (week 9), JL recalled 21 sung words after 10 min but only nine spoken words (i.e., 60 *vs.* 26.5 % of words

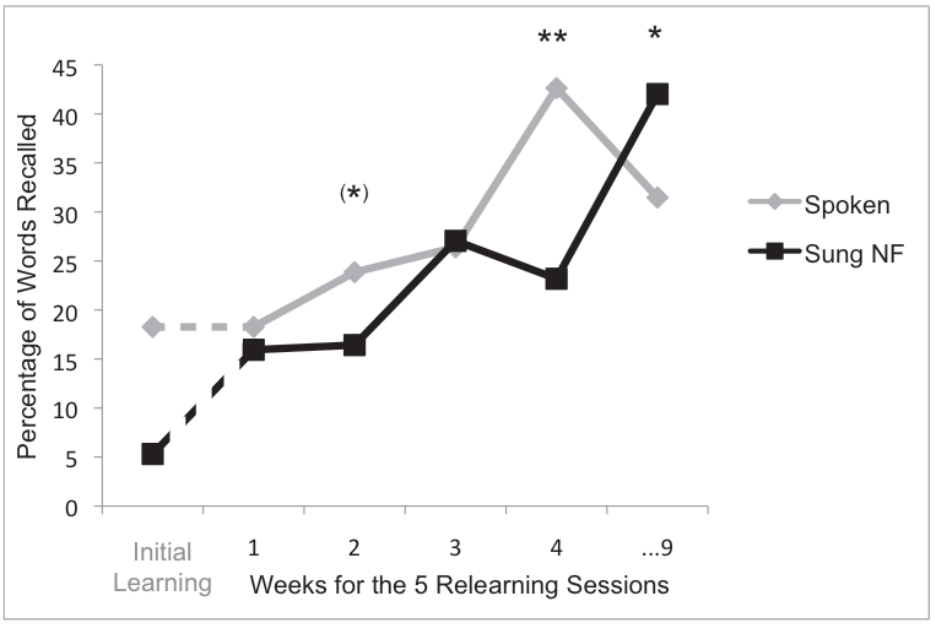

FIGURE 3. Learning scores of JL in the five relearning sessions. Percentage of words correctly recalled (out of total words). The dotted line represents the initial learning level for these two conditions (note that these data are not included for relearning statistics). Asterisks indicate a marginal or significant difference between conditions; (*) $p = .063$, * $p < .05$, ** $p < .01$.

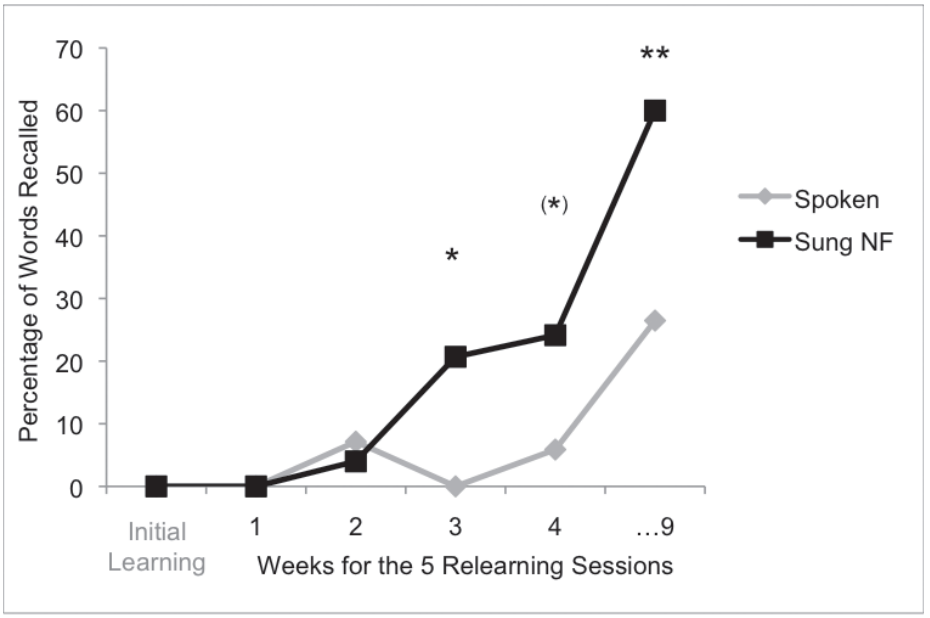

FIGURE 4. Delayed recall scores of JL in the five relearning sessions. Percentage of words correctly recalled (relative to the number of words learned 10 minutes earlier in each session). Asterisks indicate a marginal or significant difference between conditions; (*) $p = .068$, * $p < .05$, ** $p < .01$.

recalled). The learning slope across sessions was also steeper for the sung than for the spoken condition (slope = .44, $R^2 = .87$, and slope = .27, $R^2 = .82$, respectively).

Discussion

In normal adults, music can interfere with verbal learning in initial stages, and facilitate performance in long-term retention or relearning episodes. The present case study replicates these findings in a mild Alzheimer's participant and opens new perspectives both for a better understanding of memory for spoken and sung lyrics and for best practice in clinical settings.

At initial learning of lyrics, singing does not necessarily help memorization. The effect of singing on learning during this initial phase depends on prior knowledge of the melody. Learning the lyrics on an unfamiliar melody is more difficult than learning them without a melody (spoken) or on a low or high familiar melody. However, over regular relearning episodes, performance increases for both the non-familiar sung and the spoken version, and somewhat more for the sung one, despite a surprising reversal of performance in the relearning session 4. When lyrics recall are delayed by one month (week 9) or even 10 min, sung words are better recalled than spoken words. Thus, music is an aid for verbal long-term retention.

In the initial learning phase, the conditions were presented in an arbitrary order, which happened to correspond to the performance of JL. She performed worse in the first sung NF condition and best in the last sung LF condition. This increase in performance may reflect familiarization with the task. Future testing of other cases of Alzheimer disease will shed light on this order effect. At any rate, in the relearning phase and in delayed recall, when order was counterbalanced between the spoken and sung version, JL exhibited a clear advantage effect for the sung version of the lyrics.

This differential effect of music on verbal memory is consistent with the theory of dual representation of a song's lyrics and melody (Hébert & Peretz, 2001; Peretz, 1996; Peretz, Radeau, & Arguin, 2004). By this view, dual coding makes memorization demanding and slow, but when achieved, the trace is robust and retrieval from long-term memory is facilitated (Calvert & Tart, 1993; McElhinney & Annett, 1996; Rainey & Larsen, 2002; Wilson, Parsons, & Reutens, 2006). Further support for separate representations for lyrics and melody is provided by the fact that JL recalled more often sung lyrics while speaking, instead of singing. If lyrics and melody were strongly associated in a unitary representation, JL would not be able to extract the words so easily. Moreover, this ratio did not change across the relearning sessions, as it would be expected if lyrics and melody would become more and more integrated with a deeper knowledge of the sung excerpt. Yet, in long-term recall, even if more words are recalled in the sung than spoken condition, most of them are recalled in a speaking mode.

Over multiple relearning episodes, an associative link between lyrics and melody leads to a better long-term retention for the sung lyrics than for the spoken ones, with more than twice as many words during the last relearning session after a ten-minute delay. These findings are consistent with the well-established fact that a rich and deep encoding, created by associative links between elements to memorize, facilitates both storage and retrieval in long-term memory (Paivio, 1967).

The question raised by these findings concerns the efficacy of music in this associative link for the consolidation process. Only one study has shown specific consolidation for musical stimuli in moderate to severe Alzheimer's patients: after multiple exposures (eight sessions over two weeks) to instrumental pieces or poems, the patients showed a feeling of familiarity for both kinds of stimuli, but, after a two-month delay, familiarity was only present for the musical material (Samson, Dellacherie, & Platel, 2009). The authors suggest that this gain is due to the strong emotional power of music, which may enhance the consolidation of memory traces. Further studies will be needed to explore whether learning lyrics with other forms of support (such as gestures, for example) also promote consolidation in Alzheimer's participants or in healthy subjects. If music is special because of its surface characteristic effects on chunking, its specific links with language, or its interactions with emotion or arousal, other forms of support may not lead to the same benefit for long-term retention. Further studies will also have to replicate these findings in a group study. Despite the degree of investigative thoroughness allowed by a case study, its statements concerning generalization to the population of Alzheimer's patients are limited. It is therefore of interest to characterize the cognitive and/or musical profile of patients that would incur the greatest benefit from singing the verbal information to be memorized.

This study has several clinical implications. First, it shows that individuals with mild dementia can still learn new musical information, as shown by the progression of performance across sessions and weeks, even if it may require more trials than in a non-impaired participant. These findings are consistent with prior studies in other domains, such as face-name associations (e.g., Bier et al., 2008) showing that Alzheimer's participants are able to learn novel associations. Second, initial learning difficulty may not be a good predictor of how solid the memory trace will be in this population. In the initial stages, singing lyrics on a non-familiar melody can overload and interfere with learning. However, in the case of long-term care, sung material – even on unfamiliar melodies – may lead to better retention than a spoken one. Thirdly, singing instead of speaking is not necessary as long as the lyrics to be memorized are presented as a song. Finally, we wish to point out that the participant enjoyed the multiple learning sessions. The "recreational" characteristic of the musical stimulation makes it privileged material for dementia care.

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