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Preserved Singing in Aphasia: A Case Study of the Efficacy of Melodic Intonation Therapy

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This study examined the efficacy of Melodic Intonation Therapy (MIT) in a male singer (KL) with severe Broca's aphasia. Thirty novel phrases were allocated to one of three experimental conditions: unrehearsed, rehearsed verbal production (repetition), and rehearsed verbal production with melody (MIT). The results showed superior production of MIT phrases during therapy. Comparison of performance at baseline, 1 week, and 5 weeks after therapy revealed an initial beneficial effect of both types of rehearsal; however, MIT was more durable, facilitating longer-term phrase production. Our findings suggest that MIT facilitated KL's speech praxis, and that combining melody and speech through rehearsal promoted separate storage and/or access to the phrase representation.

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The last 250 years have seen a number of reports describing preserved singing (with lyrics) in aphasia (Brust, 1980, 2001). This phenomenon raises important questions about the representation of music and language functions in the brain. For example, Yamadori and colleagues (1977) found that out of 24 patients with Broca's aphasia, 12 were able to sing a well-known song with text correctly. The absence of a relationship between the severity of aphasia and text production during singing led them to conclude that singing and speech are independent functions. Considerable previous research now suggests that singing is predominantly a right-hemisphere function while speech is primarily mediated by the left hemisphere (Botez & Wertheim, 1959; Epstein et al., 1999; Geschwind, Quadfasel, & Segarra, 1968; Gleason & Goodglass, 1984; Gordon & Bogen, 1974; Jackson, 1871; Perry, Zatorre, Petrides, Alivisatos, Meyer, & Evans, 1999; Riecker, Ackermann, Wildgruber, Dogil, & Grodd, 2000; Smith, 1966; Stewart, Walsh, Frith, & Rothwell, 2001; Wildgruber, Ackermann, Klose, Kardatzki, & Grodd, 1996).

One explanation for preserved singing in aphasia is that song is a form of nonpropositional speech (Ellis & Young, 1996). First described by Jackson (1866), the distinction between propositional and nonpropositional speech is commonly used in studies of aphasic language. Jackson (1915) defined nonpropositional speech as ready-made utterances that may express emotion but are "intellectually dead," while propositional speech is an intentional expression of thought. He proposed that in the event of left hemisphere damage affecting propositional speech, sensorimotor processes in the right hemisphere may still allow nonpropositional speech (Jackson, 1874). Recent researchers have built on Jackson's ideas, defining nonpropositional speech as conventionalized, context-dependent speech that does not involve syntactic parsing or the conscious formulation of new utterances to express a semantic message (Code, 1997; Nenonen, Niemi, & Laine, 2002; Speedie, Wertman, Ta'ir, & Heilman, 1993). The notion that singing represents a form of nonpropositional speech has received variable support (Hébert, Racette, Gagnon & Peretz, 2003). Notably, Speedie and colleagues (1993) described a case with preserved speech but impaired ability to swear, recite poetry, and sing previously well-known songs following a right basal ganglia lesion.

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Proponents of Melodic Intonation Therapy (MIT) claim that pairing melody with words facilitates propositional speech in aphasic patients (Naeser & Helm-Estebrooks, 1985). A number of explanations have been proposed for this effect, the original being that melody activates right hemisphere language structures that were formerly dominated by the left hemisphere (Albert, Sparks, & Helm, 1973). A related account is that MIT increases the role of the right hemisphere in interhemispheric language control (Sparks, Helm, & Albert, 1974). Neither of these mechanisms has received recent support, however, in a positron emission tomography study of recovery from nonfluent aphasia after MIT. Specifically, Belin and colleagues (1996) found that the repetition of words with MIT reactivated Broca's area and the left prefrontal cortex while deactivating the homologue of Wernicke's area in the right hemisphere.

Donnan and colleagues (1999) have proposed that Broca's aphasia involves three different levels of language disorder: initial mutism, speech dyspraxia, and agrammatism. An alternative account of the mechanism of MIT is speech facilitation at the articulatory level, through the use of a slower tempo, a more precise rhythm, and greater accentuation than normal speech (Sparks & Holland, 1976). Slowing the tempo can lessen the neuromotor complexity of the articulatory process, as evidenced by the beneficial effect of melody on stuttering (Ham, 1990). Furthermore, syllable lengthening has been shown to aid phrase production in nonfluent aphasics using MIT (Laughlin, Naeser, & Gordon, 1979).

Despite a number of papers advocating the use of MIT (Albert et al., 1973; Baker, 2000; Naeser & Helm-Estebrooks, 1985) very few studies have employed experimental designs that allow the various mechanisms of MIT to be compared. More fundamental to this, very few studies have compared MIT with control tasks or accounted for time since injury, making it difficult to distinguish spontaneous recovery from improvements specifically related to MIT. Methodological weaknesses in the literature such as these have recently led Hébert and colleagues (2003) to question the empirical basis of the proposed beneficial effects of MIT.

Three previous studies employing control tasks have failed to show a facilitatory effect of melody on speech production. Specifically, Cohen and Ford (1995) found no differences in the speech production of 12 aphasic patients compared across three experimental conditions; verbal production only, verbal production with rhythm, and verbal production with melody. More recently, Hébert and colleagues (2003), and Peretz, Gagnon, Hébert, and Macoir (2004) reported no differences between the mean number of sung or spoken words produced by two nonfluent aphasics when using either familiar or novel stimuli. In all of these studies, however, MIT was not administered as part of the experimental design, preventing direct assessment of the efficacy of MIT.

The aim of the present study was to evaluate the efficacy of MIT using a pre- versus post-treatment design that included control tasks in a neurologically *stable* male singer (KL) with severe Broca's aphasia. KL is a right-handed amateur musician who retained the ability to sing familiar songs with lyrics following a large left frontoparietal infarct. His neurologically preserved singing provided the ideal opportunity to assess the ability of MIT to promote the production of propositional speech. Thirty novel phrases were generated and allocated to one of three experimental conditions: unrehearsed, rehearsed verbal production (repetition), and rehearsed verbal production with melody (MIT). The unrehearsed condition served as the control for the rehearsed conditions (i.e., the effect of no intervention). The rehearsed conditions entailed twice-weekly practice sessions for a period of 4 weeks under the guidance of a Registered Music Therapist. Rehearsed verbal production assessed the effects of practice using an accentuated rhythm as opposed to melody during training. The immediate and longer-term efficacy of MIT was assessed by comparing KL's performance at baseline, 1 week, and 5 weeks after therapy. The results are discussed in light of the proposed mechanisms of MIT.

Methods

Case KL

KL was a right-handed amateur male musician born in 1949. Following informed consent from KL and his sister, he participated in this study between March 2001 and June 2002. In May 1997, KL sustained a left middle cerebral artery tertiary stroke. Initial examination revealed a dense right hemiparesis and global aphasia. Since 1998, he has suffered infrequent focal motor seizures affecting the right hand with infrequent secondarily generalization.

Magnetic resonance imaging (MRI) performed 3 years post-injury revealed dilatation of the left lateral ventricle and an infarct extending anteriorly to the middle frontal gyrus and posteriorly to the inferior parietal lobe. Marked cortical thinning of the left middle and superior temporal gyri and insular cortex and damage to the left basal ganglia were evident (see Figure 1).

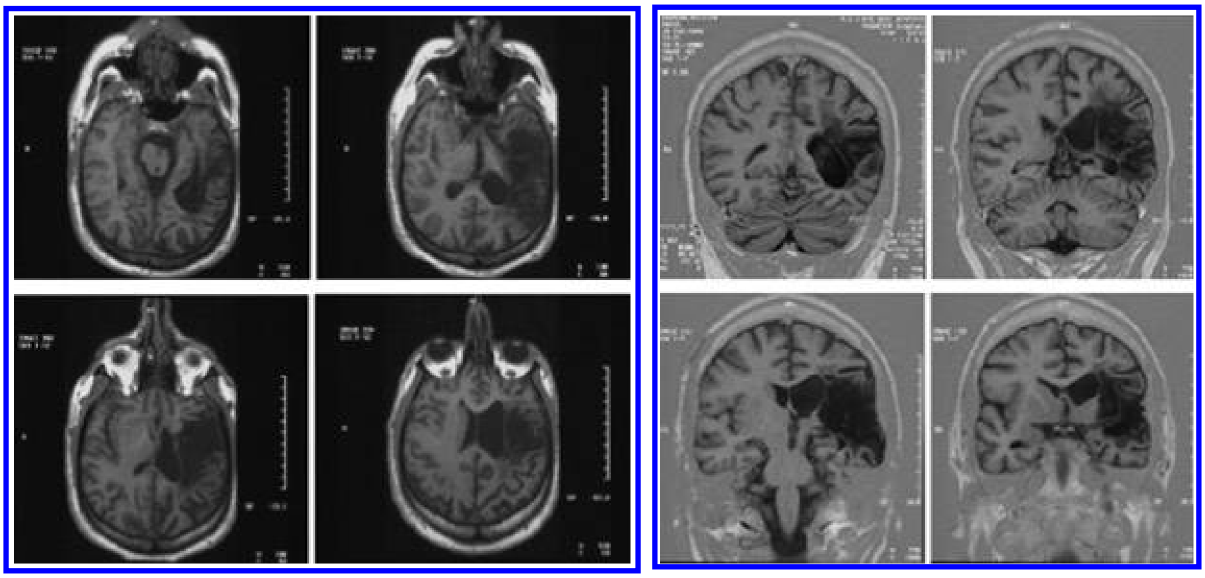

FIG. 1. Axial and coronal magnetic resonance imaging (MRI) scans of KL's left frontoparietal lesion, taken 3 years post-stroke. The right hemisphere appears on the left-hand side of the scan.

Four years post-injury, KL presented with a stable, severe expressive aphasia. His spontaneous speech was limited to counting to 10 and simple words that were produced with preserved articulation and prosody (e.g., "yes," "no," "look"). At a conversational level, KL showed preserved language comprehension and was able to communicate through gesture, facial expression and the use of props (e.g., photographs). He required the listener to establish the topic, ask yes/no questions, and clarify the message given or received.

KL was a self-taught musician and was the lead singer of a blues/rock band for 25 years prior to his stroke. He also played the piano and the harmonica, and had composed approximately 40 original songs for the band. Post-stroke he retained the ability to hum, and 1 year post-injury he was able to sing familiar songs with lyrics following practice with a music therapist and friends.

NEUROPSYCHOLOGICAL PROFILE

KL was university educated and taught English and Politics at secondary school for 30 years prior to his stroke. He had a performance IQ (PIQ) of 79 as measured on the Wechsler Adult Intelligence Scale-III (Wechsler, 1997). This was below his expected premorbid level but consistent with the location and extent of his infarct. In particular, KL's low PIQ reflected marked difficulties with psychomotor speed (Processing Speed Index = 69) and more subtle difficulties with visuospatial functioning (Perceptual Organization Index = 86). In contrast, his nonverbal memory function measured using the Wechsler Memory Scale-Revised (Wechsler, 1987) fell within the normal range (Visual Memory Index = 95, Visual memory span of six items forward and backward).

The Boston Diagnostic Aphasic Examination (BDAE; Goodglass & Kaplan, 1972) revealed that KL's language problems are primarily related to expression; however, he also showed comprehension difficulties typical of classical Broca's aphasia (see Table 1). In the expressive domain, KL showed poor verbal agility. His articulation was normal only for a limited number of familiar words that he could use in phrases no longer than two words (e.g., "Yes, but . . ."). He displayed evidence of verbal apraxia, correctly repeating words only by closely copying the speaker's articulation. He was unable to repeat or read aloud phrases, name objects, or respond to simple questions even though he demonstrated he knew the answers. His writing skills paralleled his spoken speech; he could copy words but not compose his own sentences. He was able to write his name and serial sequences without copying, but could not write to dictation or perform the more complex written tasks of the BDAE.

In the receptive domain, KL's comprehension difficulties were most evident on the Ideational material task, which requires a yes/no response to questions unrelated to the immediate context (e.g., "Will a stone sink in water?"). In contrast, he could follow group conversations quite easily, highlighting his use of contextual cues to understand speech. He showed a strength on the performance of written comprehension tasks, correctly matching printed words with spoken words or pictures, and choosing the appropriate word to 'fill the

TABLE 1. **Assessment of KL's language skills using the Boston Diagnostic Aphasic Examination**

Task	Score	Comments
Oral expression		
Verbal agility[a]	3/14	
Repeating words	8/10	
Repeating phrases	1/16	
Reading aloud words[b]	4/10	
Reading aloud phrases[b]	0/10	
Answering simple questions	0/10	e.g., "What do we tell the time with?"
Naming	0/35	
Body-part naming	0/10	
Written expression		
Name and address	√	
Serial sequences		
Alphabet	15/26	
Numbers 1–21	21/21	
Dictation	2/15	Included letters, numbers and words
Auditory comprehension		
Body part discrimination	6/26	Difficulty with "right" and "left"
Commands	7/15	Difficulty with commands > 3 sequences
Word-picture matching		
Colors	0/6	Accurate performance of Ishihara's color vision test
Numerals	3/6	
Letters	2/6	
Objects	6/6	
Shapes	6/6	
Verbs	6/6	
Ideational material	5/12	Used contextual cues to follow informal group conversations
Written comprehension		
Word-picture matching		
Colors	2/2	
Numerals	1/2	
Shapes	2/2	
Objects	2/2	
Verbs	2/2	
Spoken-written word matching	5/8	
"Fill in the gaps"	6/10	

[a] Verbal agility is a measure of the number of times an individual can repeat words as accurately as possible in 5 seconds.
[b] KL retained the ability to read written text. Difficulties reading aloud primarily reflected his impaired speech production.

gap' in sentences. Interestingly, he showed a dissociation between the correct matching of colors to their written names but not their spoken names (see Table 1).

Experimental tasks similar to those designed by Linebarger and colleagues (1983) and Carramazza and Hillis (1989) were used to assess KL's grammatical skills. In the first task, pairs of sentences were presented both visually (printed on cards) and aurally (read aloud), and KL was required to identify the grammatically correct sentence within each pair (Linebarger, Schwartz, & Saffran, 1983). In the second task, KL was required to construct grammatically correct sentences from printed word cards presented in random order (Carramazza & Hillis, 1989). KL performed well on the grammatical judgment task (16/18 pairs correct); however, he was unable to construct eight of the nine sentence anagrams. These findings are consistent with the above results and suggest that KL's grammatical representation was largely intact; however, he was unable to produce his own grammatical structures.

KL did not show the classic dissociation between nonpropositional and propositional speech production (see Table 2). He performed poorly on the automatic speech tasks of the BDAE, as well as a phrase completion task specifically designed by Lum and Ellis (1994) to assess this dissociation. This latter task comprises 30 phrases requiring completion, which are either familiar (nonpropositional) or unfamiliar (propositional)—for example, (1) familiar phrase, "As green as *grass*," and (2) unfamiliar phrase, "As long as *grass*." KL's performance ranked in the bottom quartile for both types of phrases indicating impairments in both automatic and propositional speech (see Table 2).

KL's performance of the Supplementary ideomotor tasks of the BDAE was symptomatic of ideomotor apraxia. He tended to verbalize actions and used a finger as the mimed object in the transitive limb tasks.

MUSICAL SKILLS

KL indicated that he listened to music daily and occasionally played the keyboard and harmonica left-handed; however, he no longer composed music. His musical abilities were assessed using the Measures of Musical Abilities (Bentley, 1985) and standard items from the aural assessment tasks of the Australian Music Examinations Board (Nickson & Black, 1962). The results showed that KL's musical abilities generally fell within the normal range; however, his discrimination and production of more complex, novel rhythmic patterns were severely impaired (see Table 3). In contrast, he could still maintain a steady beat to music and when unaccompanied.

KL also showed impaired pitch working memory as tested using Zatorre's pitch short-term memory task (Zatorre & Samson, 1991). This most likely hampered his ability to accurately reproduce more complex novel melodies, despite singing tuneful harmonies and

TABLE 2. Assessment of the nonpropositional/propositional speech dichotomy

Task	Performance	Comments
Boston Diagnostic Aphasic Examination		
Counting to 10	Unimpaired	
Expletives	Unimpaired	
Reciting days of the week	Impaired	Difficulty with "Wednesday"; "Saturday" was said as "Sunday"
Reciting the alphabet	Impaired	Only able to say "a, b, c, d"; singing the alphabet song did not facilitate performance
Reciting months of year	Impaired	
Reciting nursery rhymes[a]	Impaired	Able to say some words with continuous prompting
Phrase completion task		
Familiar phrases	12/30	25th percentile[b]
Unfamiliar phrases	6/30	25th percentile[b]

[a] Nursery rhymes included "Jack and Jill" and "Baa Baa Black Sheep."
[b] From Lum & Ellis (1994).

familiar melodies throughout the duration of the study. He demonstrated the ability to learn new songs as well as "relearn" songs he had performed pre-stroke. Interestingly, he was unable to sing the unrehearsed name in "Happy Birthday to You" and would leave a space for the listener to fill. He was not able to hold a conversation through song and often needed prompting to begin singing.

TABLE 3. Assessment of KL's musical skills

Task	Score	Norms
Measures of musical abilities		
Pitch discrimination	17/20	18.0 (± 1.9)[a]
Melody discrimination	8/10	8.8 (± 1.0)[a]
Chord discrimination	13/20	13.8 (± 2.9)[a]
Rhythm discrimination	0/10	8.3 (± 1.0)[a]
AMEB aural tasks[b]		
Novel pitch production		
Short melodies	3/5	
Long melodies	0/5	
Novel rhythm production	1/4	KL was able to tap the rhythms of highly familiar songs
Zatorre's pitch short-term memory task		
Control condition	24/24	
Interference condition	16/24 (33.3% error)	6% (± 2.5) error for healthy adults; 12% (± 2.6) error for left temporal lobectomy patients[c]

[a] Taken from Wilson & Pressing (1999) for males aged between 62 and 70 years.
[b] Australian Music Examinations Board (Nickson & Black, 1962).
[c] Data from Zatorre & Samson (1991).

Materials

Thirty phrases of three words were generated and randomly allocated to one of three groups of ten. Each phrase was printed beneath a line drawing of the last word. Some of these drawings were taken from the Boston Naming Test (Goodglass & Kaplan, 1972) while the remainder were created in a similar style. Each group had a similar number of phrases with one-, two-, three-, or four-syllable words.

Tunes were composed for each of the Group 1 (MIT) phrases. The rhythm and pitch contour of the tunes were similar to the rhythm and prosody of conversational speech (see Figure 2), although this aspect was occasionally sacrificed to make each tune unique, as suggested by Baker (2000). Group 2 (repetition) phrases were given a slightly exaggerated rhythm that approximated the rhythms of Group 1 without violating the natural rhythm of speech (see Figure 2). Group 1 and 2 phrases were recorded onto a practice compact disc (CD) by a professional singer using personal computer recording software (Sound Forge 4.5b, Sonic Foundry). The phrases were presented on the CD in the same order as they were rehearsed during therapy sessions, beginning with the easy phrases. Group 3 phrases were unrehearsed.

Procedure

Throughout testing, KL's responses were recorded using a portable digital audiotape (DAT) recorder. Baseline performance was obtained prior to the commencement of therapy, by asking KL to say the phrases from each group in response to picture prompts, written word prompts, and spoken word prompts. Therapy was

FIG. 2. Examples of the experimental stimuli. Group 1 phrases were sung while Group 2 phrases were spoken with a slightly exaggerated rhythm.

TABLE 4. Melodic Intonation Therapy procedure (Helm-Estebrooks, 1983)

Level	Group 1 phrases (MIT)	Group 2 phrases (repetition)
1	Therapist hums melody and taps rhythm	Therapist taps rhythm
2	Therapist intones phrase and taps rhythm	Therapist recites phrase and taps rhythm
3	Therapist intones phrase and taps rhythm with KL	Therapist recites phrase and taps rhythm with KL
4	Therapist intones phrase with KL, gradually fading out assistance	Therapist recites phrase with KL, gradually fading out assistance
5	KL sings phrase after therapist	KL repeats phrase after therapist
6	KL answers a question using the sung target phrase	KL answers a question using the spoken target phrase

then conducted for a period of 4 weeks by a Registered Music Therapist and the second named researcher. It entailed twice-weekly rehearsal sessions of both Group 1 and 2 phrases with the hours of training identical for each condition. Rehearsal followed the MIT method outlined by Helm-Estebrooks (1983) that includes six levels of phrase production graded according to the level of phrase difficulty and the degree of prompting provided by the therapist (see Table 4). The highest level (level 6) requires the participant to answer a question using the target phrase. KL was allowed three attempts to complete each level, and melody was not incorporated into the rehearsal of Group 2 phrases. He was encouraged to use the practice CD between sessions and his practice records showed that he did not favor one type of rehearsal over the other. Group 3 (unrehearsed) phrases were presented at baseline and at week 5, one week after the cessation of therapy (follow-up 1).

At follow-up 1, the phrases from each group were presented to KL in random order. For each phrase, he was first given a picture prompt, then a melodic prompt (for the MIT phrases only), a written word prompt, and finally a spoken or sung word prompt, until he was able to say the complete phrase. The melodic and sung word prompts used the melodies accompanying the Group 1 phrases. A similar follow-up assessment of the rehearsed phrases was conducted at week 9, five weeks after the cessation of therapy (follow-up 2). KL did not use his practice CD between follow-up 1 and 2.

A number of performance indicators were used to assess KL's phrase production. First, during therapy the highest level reached by KL for each phrase was recorded for the purpose of analyzing the number of times he reached Level 6 as a function of MIT versus repetition training. Second, his baseline and follow-up test performances were quantified using a scoring system similar to that devised by Lum and Ellis (1994). Specifically, a weighting system was used to reflect the varying difficulty of the prompts and to control for the number of syllables in each phrase (phrase length). Additionally, the production of a complete and immediately correct phrase without verbal cueing was allocated an extra two points (see Table 5). For example, an immediately correct three-syllable phrase in response to a picture prompt received a score of 8 (2 points for each syllable plus an extra 2 points for the complete phrase). The total was then divided by 6 to reflect only the use of a picture prompt to complete the phrase (see Table 5). Finally, the nature of KL's production errors was recorded to allow potential mechanisms underlying his difficulties to be examined relative to the presence or absence of training

TABLE 5. **System used to score KL's performance (after Lum & Ellis, 1994)**

Utterance		Score[a]		Score[b]
Correct syllable (e.g., "fish")		2		1
Approximation (e.g., "frish")		1		1/2
Complete phrase (e.g., "A cold fish")		2 + 2 + 2 + extra 2 = 8		1 + 1 + 1 = 3
Phrase length	Picture prompt	Melodic prompt	Written prompt	Spoken/sung prompt
3 syllables	score/6	score/9	score/11	score/12.5
4 syllables	score/8	score/12	score/14.67	score/16.67
5 syllables	score/10	score/15	score/18.3	score/20.8
6 syllables	score/12	score/18	score/22	score/25

[a]Without simultaneous verbal cueing.
[b]With simultaneous verbal cueing.

and the type of training received (repetition versus MIT). Of particular interest was the number of articulation errors produced by KL compared with paraphasic errors. For the purpose of coding, identifiable word approximations were classified as articulation errors. Paraphasic errors comprised word substitutions with possible phonological resemblance but no semantic resemblance to the target word. Incomplete attempts at phrases as well as the absence of an attempt were also noted.

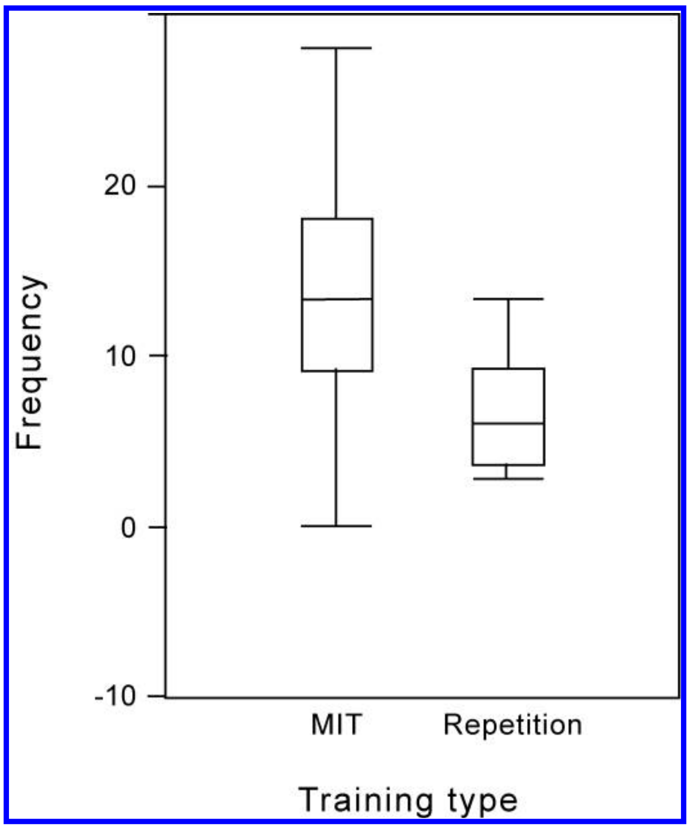

FIG. 3. **Box plot showing the mean number of times KL reached Level 6 for Group 1 and 2 phrases during training. The box plot visually displays the distribution of the data, with the box representing the 25th to 75th percentile scores, and the median value indicated by a line across the box.**

Results

Performance During Therapy: MIT versus Repetition Training

Exploratory data analysis revealed that the data were suitable for parametric analyses that were performed using SPSS statistical software. To examine the effects of MIT during training, a *t* test was used to compare the mean number of times KL reached Level 6 across the eight sessions of therapy as a function of the type of training. As shown in Figure 3, a significant performance advantage was evident for phrases rehearsed using MIT versus those rehearsed using repetition, $t(14) = 2.27$, $p < .05$.

Immediate Efficacy of MIT: Baseline versus Follow-up 1

A repeated measures analysis of covariance (ANCOVA) was used to examine the proportion of words correctly produced by KL as a function of time of assessment (baseline versus follow-up 1) and phrase group (1–3). Phrase length was used as the covariate in the analysis. The results showed a significant main effect of time, $F(1, 56) = 6.47$, $p < .05$, and phrase group, $F(2, 56) = 13.9$, $p < .001$, and a significant interaction between time and group, $F(2, 56) = 9.95$, $p < .001$. Phrase length had no significant effect, $F(1, 56) = 0.35$, *n.s.* As shown in Figure 4, pairwise comparisons of the estimated marginal means revealed that KL's performance of the MIT and repetition phrases was significantly better than his performance of the unrehearsed phrases across time (baseline and follow-up 1). In contrast, the difference between his overall performance of the MIT and repetition phrases was not significant.

Longer-term Efficacy of MIT: Baseline versus Follow-up 1 & 2

A repeated measures ANCOVA was used to assess the longer-term efficacy of MIT by examining the proportion of words correctly produced by KL for the

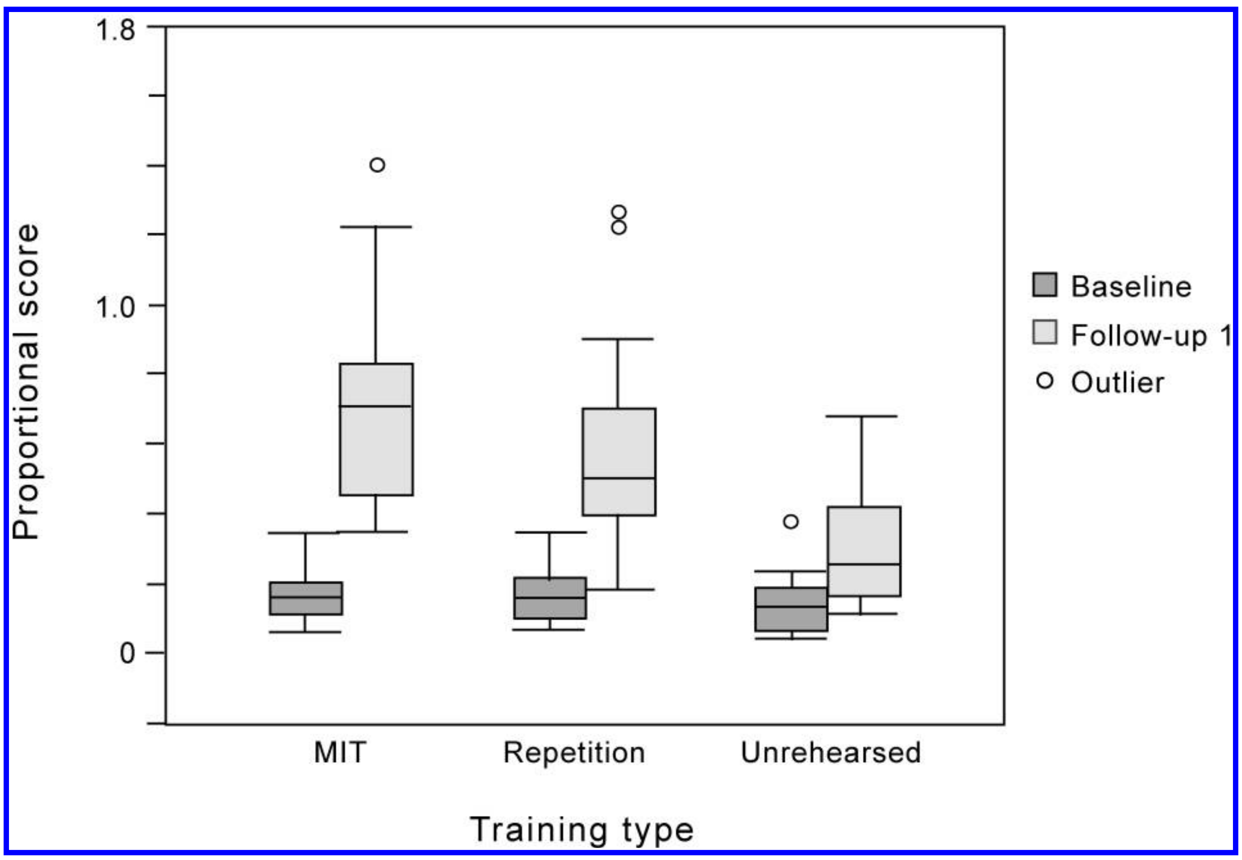

FIG. 4. Box plot showing the proportion of words correct at baseline and follow-up 1 as a function of training. Differences between the estimated marginal means collapsed across time were as follows: (1) MIT − Repetition = 0.07, *n.s.*, (2) MIT − Unrehearsed = 0.21, $p < .001$, and (3) Repetition − Unrehearsed = 0.15, $p < .01$.

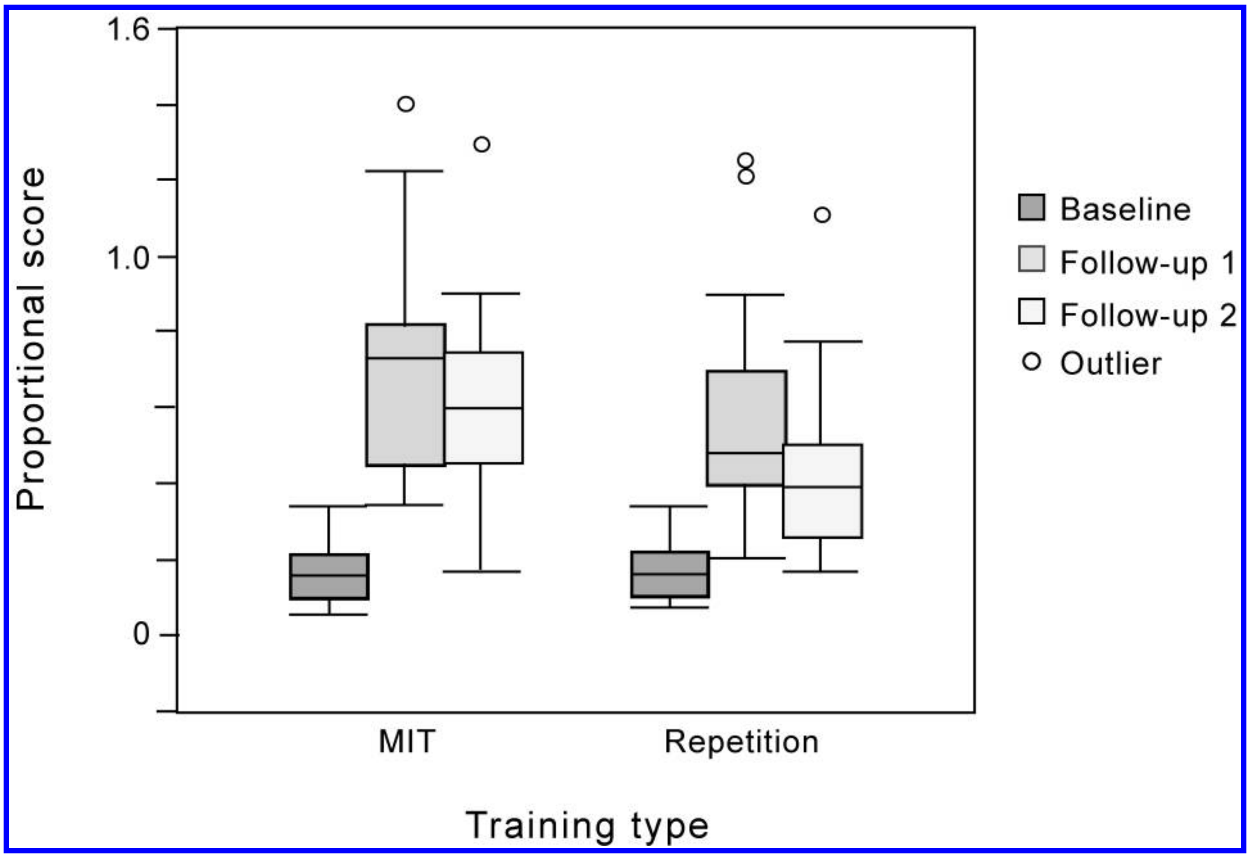

FIG. 5. Box plot showing proportion of words correct at baseline, follow-up 1 and follow-up 2 for rehearsed phrases. Parameter estimates for the MIT versus repetition phrases were as follows: (1) Baseline; B = −.002, t = −0.1, *n.s.*, (2) Follow-up 1; B = .13, t = 1.44, *n.s.*, and (3) Follow-up 2; B = .18, t = 2.3, $p < 0.05$.

rehearsed phrases (MIT versus repetition) as a function of time (baseline versus follow-up 1, 2). Phrase length was again used as the covariate in the analysis. The results showed a significant main effect of phrase group, $F(1, 37) = 5.08$, $p < .05$, and a significant interaction effect between time and group, $F(1, 37) = 5.4$, $p < .05$. In line with the previous analysis, parameter estimates indicated that there was no difference between KL's performance of the MIT and repetition phrases at baseline and follow-up 1. His performance of the repetition phrases, however, deteriorated at a faster rate than the MIT phrases, creating a significant performance advantage for the MIT phrases at follow-up 2 (see Figure 5).

TABLE 6. Breakdown of KL's production errors (%) as a function of phrase group

Performance	Group 1 (MIT)	Group 2 (repetition)	Group 3 (unrehearsed)
Correct response	8	6	–
Correct with cue	9	15	7
Incomplete phrase	19	32	26
Other MIT phrase	12	3	13
Other repetition phrase	–	6	2
Other unrehearsed phrase	–	3	5
Articulation error	34	27	34
No attempt	18	8	13

Error Analysis

Table 6 displays the types of production errors made by KL relative to the number of correct responses (with or without a prompt), shown as a function of phrase group. In all three groups, production errors included the absence of a phrase attempt, an incomplete phrase attempt, articulation errors, and paraphasic errors. Examination of the paraphasic errors revealed that they naturally subdivided according to word substitutions from other MIT phrases, other repetition phrases or other unrehearsed phrases (see Table 6). Across the three groups, the majority of errors related to articulation problems (M = 31.67%), followed by incomplete phrase attempts (M = 25.67%). The frequency of correct responses with or without a cue (M = 15%) was similar to the number of paraphasic errors collapsed across subdivisions (M = 14.67%) and the absence of phrase attempts (M = 13%).

For MIT phrases, KL's paraphasic errors only consisted of other words or phrases that had been rehearsed with melody. This suggests that the melodic prompts facilitated access to words that had been rehearsed with melody over those that had not. Similarly, for repetition phrases, the majority of paraphasic errors comprised word substitutions from other repetition phrases, compared with other MIT or unrehearsed phrases. The majority of paraphasic errors in the unrehearsed group comprised other MIT phrases. This suggests that in the absence of any rehearsed articulation pattern, the MIT phrases dominated over the nonmelodic phrases. Overall, the MIT phrases showed the highest correct response rate without a prompt, whereas repetition phrases were more likely to be correct with a verbal cue. MIT was also associated with the lowest number of incomplete phrases, in contrast to the highest number for repetition phrases. Finally, unrehearsed phrases showed the lowest number of correct responses (with or without a prompt) and the highest number of paraphasic errors, supporting the general benefits of rehearsal.

Discussion

This study provides an important step in demonstrating the efficacy of MIT in a neurologically stable amateur male musician with severe expressive aphasia using a controlled pre- versus post-treatment design. In particular, during therapy KL was significantly more likely to reach the stage where he could answer a question with a sung target phrase than a spoken phrase. Although sung or spoken rehearsal had a short-term beneficial effect on his word production compared with no training, the effects of MIT were more durable, facilitating superior phrase production 5 weeks after therapy. MIT phrases were also more commonly produced without a prompt and were more likely to be complete utterances.

The lack of an effect of melody on speech production in previous research using control tasks with aphasic patients may be explained by the absence of training in these studies (cf. Cohen & Ford, 1995; Hébert et al., 2003; Peretz et al., 2004). Rehearsal was of paramount importance for KL's speech production, facilitating both melodic and nonmelodic phrases. The effect of rehearsal provides an important clue about the possible mechanisms underlying the efficacy of MIT in this case. Specifically, MIT appeared to facilitate KL's most obvious difficulty with correctly articulating speech sounds. In fact, rehearsal generally aided his articulation and sequencing of speech sounds, as evident from the immediate and beneficial effects of both MIT and repetition. Both of these strategies employed a more pronounced rhythm, which had the effect of slowing the tempo and providing greater accentuation of the speech sounds, likely reducing the complexity of the speech production process (Sparks & Holland, 1976). Interestingly, the additional use of pitch in the MIT phrases had a longer-term effect of facilitating phrase production, highlighting the importance of the melodic component in MIT.

The relative contribution of pitch and rhythm in the efficacy of MIT is an unresolved issue. Boucher and colleagues (2001) previously examined the effects of pitch versus rhythm on speech production in two aphasic patients, reporting that rhythm facilitated speech articulation to a greater degree than the tonal attributes of speech. Their paradigm, however, did not utilize MIT preventing direct comparison of their findings. KL's overall pattern of performance suggests that the tonal attributes of MIT had less impact on speech articulation and more impact on phrase encoding or access at a cognitive level. Specifically, a beneficial, articulatory effect of melody above that provided by rhythm should have been evident as superior MIT phrase performance immediately after therapy (i.e., MIT > repetition across baseline and follow-up 1). The advantage of melodic over nonmelodic rehearsal, however, appeared as a delayed recall effect (follow-up 2). This may indicate that the act of combining melody and speech promoted different storage or access to the sung phrases that became apparent once the initial benefits of rehearsal had subsided, resulting in more effective, longer-term production in the presence of expressive aphasia.

This interpretation is consistent with observations of isolable processing systems for speech and music (Hébert et al., 2003; Marin, 1982; Peretz & Coltheart, 2003; Peretz & Morais, 1993). KL's production errors are also consistent with this interpretation. Specifically, his paraphasic errors of MIT phrases only consisted of other MIT phrases, supporting separate representations or access to rehearsed sung phrases and verbally repeated phrases. Use of the melodic representation appeared to dominate in the presence of expressive aphasia, giving rise to the higher incidence of MIT paraphasias in the unrehearsed condition. In contrast, KL's representation of verbally repeated phrases appeared more difficult to access, requiring a greater degree of verbal cueing and resulting in more frequent incomplete utterances. Overall, our findings may account for the previously reported paradoxical effect in the literature of preserved singing of familiar songs in patients with expressive aphasia, but the lack of an effect for *unrehearsed* sung over spoken novel stimuli in such patients (Cohen & Ford, 1995; Hébert et al., 2003; Peretz et al, 2004; Smith, 1966; Yamadori et al., 1977). In other words, *melodic rehearsal* appeared to be the key component for effecting longer-term improvements in speech production.

The classic dissociation between nonpropositional and propositional speech production was not supported in this case, rather KL showed impairments in both domains. Four weeks of intensive MIT did not appear to facilitate KL's spontaneous propositional speech, contrary to previous reports in the literature (Albert & Sparks, 1973; Naeser & Helm-Estebrooks, 1985; Sparks et al., 1974). It is possible that 4 weeks of therapy did not allow sufficient time to observe any effects on generative speech (Baker, 2000). On the other hand, patients in previous studies have begun MIT soon after the onset of aphasia, and may have recovered generative speech regardless of therapy. Given the findings of this study, it is likely that a longer course of therapy would have allowed the formation of close associations between a larger range of melodies and phrases. This, in turn, could have augmented the number of well-rehearsed, sung phrases incorporated in daily conversations. It seems unlikely, however, that a longer course of therapy would have facilitated KL's generative speech production per se. Rather, his generative impairment appeared pervasive, affecting not only the production of grammatically correct linguistic structures but also, possibly, the ability to compose new music. The ability of MIT to affect a transfer of learning to everyday speech is an important issue that warrants further investigation through the use of an experimental paradigm of sufficient length directly targeting this issue.

Finally, the dissociation in KL's rhythmic skills was consistent with previous amusic cases, and provides support for isolable processing subsystems within the music domain (Peretz, 1993; Peretz et al., 1994; Wilson & Pressing, 1999). In particular, KL was able to maintain a steady beat when unaccompanied or in response to music, despite an impairment of more complex rhythmic pattern discrimination and reproduction. Peretz (1990; Peretz & Morais, 1993) has previously ascribed this dissociation to the role of the left hemisphere in local rhythmic functions such as grouping, while the right hemisphere mediates global features such as meter. We have recently reported the case of a musician (HJ) with the reverse pattern of rhythmic deficits following a right temporoparietal infarct (Wilson, Pressing, & Wales, 2002). Specifically, HJ showed impaired ability to maintain a steady beat despite accurate discrimination of nonmetrical rhythmic patterns. Importantly, KL's disturbance of more complex rhythmic processing did not appear to prevent adequate performance of the MIT and repetition phrases used in the current study.

While it is acknowledged that the results of this study are necessarily limited to a single case, we believe they highlight a number of generic issues in this area of research. Most notably, we have demonstrated the importance of using a pre- versus post-treatment design that accounts for confounding factors such as spontaneous recovery, to assess the efficacy of MIT. In the clinical setting, the need to use MIT is relatively infrequent, pertaining to a certain type of neurological insult with associated cognitive effects. In this regard, KL presented as an ideal candidate in which to assess the efficacy of MIT. His background as an amateur singer provided a high level of motivation for him to engage in the study. Arousal in response to music has been well documented in both musicians and nonmusicians (Crncec, Wilson, & Prior, 2006), highlighting more generally the potential benefits of music.

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