From Singing to Speaking: Why Singing May Lead to Recovery of Expressive Language Function in Patients with Broca's Aphasia

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Introduction

MIT

Melodic Intonation Therapy
Introduction

Melodic Intonation Therapy (MIT) is a therapeutic process used by music therapists and speech-language pathologists to help patients with communication disorders caused by damage to the left hemisphere of the brain.
Introduction

https://www.youtube.com/watch?v=fRmukH4SH7w&list=RDfRmukH4SH7w#t=139
Aphasia

Of the estimated 600,000-750,000 new strokes occurring in the US each year approximately 20% result in some form of aphasia.
Aphasia (difficulty speaking, reading, writing, recognizing the names of objects, and/or understanding what other people have said.)

- Fluent
- Nonfluent

Nonfluent aphasia (as in the patients to be discussed here)
Location
patients with severely nonfluent aphasia are better at singing lyrics

MIT (unproven)

engage/unmask language-capable regions in the unaffected right hemisphere
Current research

1. Two patients with similar impairments and stroke size/location

2. Groups
   • MIT
   • SRT
MIT’s background

Since the initial account of its successful use in three chronic, nonfluent (Broca's) aphasic patients, reports have outlined a comprehensive program of MIT including strict patient selection criteria and data that showed significant improvement on the Boston Diagnostic Aphasia Examination after treatment

Wilson, Parsons, and Reutens (2006)
(Albert, Sparks, & Helm, 1973)
(Helm-Estabrooks & Albert, 1991; Sparks & Holland, 1976)
(BDAE; Goodglass & Kaplan, 1983)
(Helm-Estabrooks, Nicholas, & Morgan, 1989)
(Bonakdarpour, Eftekharzadeh, & Ashayeri, 2000; Sparks, Helm, & Albert, 1974).
Background studies

In a case study comparing MIT to a non-melodic control therapy, Wilson, Parsons, and Reutens (2006) found that MIT had a general facilitating effect on articulation, and a longer-term effect on phrase production that they attributed specifically to its melodic component. However, the outcomes of that study were measured by the patient's ability to produce practiced phrases prompted by the therapist, rather than by the transfer of language skills to untrained structures and/or contexts.
MIT’s features

• Voicing
• Tapping
Frequency

MIT engages patients in intensive treatment totaling
• 1.5 hrs/day
• five days/week
until the patient has mastered all three levels of MIT.
Shared features

1. the slow rate of vocalization (one syllable/s)

2. an administration protocol that includes one-on-one sessions with a therapist who introduces and practices words/phrases using picture cues while giving continuous feedback.
Background

Albert et al., 1973; Sparks et al., 1974 claimed that it engaged expressive language areas in the right hemisphere.

Alternatively, since MIT incorporates both melodic and rhythmic aspects of music, it may be unique in its potential ability to engage both hemispheres.
Background Belin

Belin et al. (1996) suggested that MIT-facilitated recovery was associated with the reactivation of left-hemisphere regions, most notably the left pre-frontal cortex, just anterior to Broca's region.
Background

• Two out of seven patients had Broca's aphasia; the rest were diagnosed with global aphasia

• they conducted only one imaging session, which took place after therapy (no pre-/ post- comparison).

• their analysis was done in predefined regions of interest rather than across the entire brain space.

N.B. blood flow changes that occurred predominantly in the right hemisphere
Aim

1. To describe and discuss the unique and shared elements of MIT
2. To contrast the behavioral and neural treatment effects of MIT with a control intervention, Speech Repetition Therapy (SRT)
Patients

• severe nonfluent aphasia (left hemisphere ischemic stroke)
• Had already received more than one year of traditional speech therapy
• They presented with significantly impaired verbal output
• Both patients were tested twice to establish a stable baseline (+0, +4)
Participants (2 patients)

1\textsuperscript{st} patient
- Male
- age 47
- right-handed
- native language English
- 12+ years of schooling
- 2-3 years of instrumental practice as a child
- moderate to severe right hemiparesis
- independent in activities of daily living
- underwent an intensive course of MIT
- 13 months after stroke

2\textsuperscript{nd} patient
- Male
- age 58
- right-handed
- native language English
- 12+ years of schooling
- 1-2 years of instrumental practice as a child
- moderate to severe right hemiparesis
- independent in activities of daily living
- underwent an equally intensive alternative intervention, SRT (speech repetition therapy)
- 12 months after stroke
Assessment

The patients were examined twice after 40 and 75 meeting

The proportion of spoken CIUs/total words possible was significantly lower than the proportion of sung CIUs/total words in both patients.
Boston Diagnostic Aphasia Examination
Boston Diagnostic Aphasia Examination

3-5 hours
5 sections

1. Conversational Speech
2. Auditory Comprehension
3. Oral Expression
4. Understanding Written Language
5. Writing
Boston Diagnostic Aphasia Examination
Boston diagnostic Aphasia

3 aims

- Diagnostic of presence and type of Aphasic Syndrome
- Measurement of level of performance
- Assessment of strengths and weaknesses
This test was used in order to establish a stable baseline
Test-short battery

1. Conversational interview: regarding patients' biographical data, medical history, poststroke treatment, daily activities, etc
2. Descriptions of complex pictures
Experimental Stimuli and fMRI Paradigm

A list of 16 bisyllabic words/phrases that both patients were capable of saying at baseline were used for stimuli in the fMRI experimental task at all imaging time points, and the rate of speaking/singing (one syllable/s) remained constant throughout the study.
Experimental Stimuli and fMRI Paradigm

The functional task consisted of five conditions:

1. two experimental (spoken or sung bisyllabic words/ phrases)
2. three control (humming, phonation, and silence).
Method

1. Participants heard an investigator saying/singing two-syllable words or phrases, then repeated exactly what they had heard after an auditory cue.

2. In the silence condition, participants were asked to wait for the cue, then take a breath as if to respond as they had in the other conditions.
Treatments

Common
• one-on-one
• the same therapist
• 1.5 hours/day,
• five days/week
• a set of materials for daily home practice
• the length of phrases, the use of picture stimuli
• the level of support provided by the therapist

Different
• SRT phrases were spoken
• syllables were not sustained
• no hand tapping
High-resolution, T1-weighted images show the chronic, left-hemisphere lesion location and extent of Patients #1 and #2, encompassing both Broca's region and the anterior part of the superior temporal lobe.
Results Behavioral and Imaging Effects of the MIT Intervention

• Patient #1, who was 13 months post onset of a left-hemispheric stroke
Results Behavioral and Imaging Effects of the MIT Intervention

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- two pre-treatment assessments separated by 4 weeks
Results Behavioral and Imaging Effects of the MIT Intervention

• Patient #1, who was 13 months post onset of a left-hemispheric stroke
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• two pre-treatment assessments separated by 4 weeks
• Mid 40
Results Behavioral and Imaging Effects of the MIT Intervention

- Patient #1, who was 13 months post onset of a left-hemispheric stroke
- MIT
- two pre-treatment assessments separated by 4 weeks
- Mid 40
- After 75
- Improvement after 40 sessions
Results Behavioral and Imaging Effects of the SRT Intervention

- Patient #2 was 12 months post onset of a left-hemispheric stroke
- was assigned to treatment with SRT.
- baseline speech production rate were similar to that of Patient #1
- After 40 SRT sessions, Patient #2's speech production scores improved, his picture-naming score increased
Results

- the posterior superior temporal gyrus (STG)
- superior temporal sulcus (STS)
- middle to inferior precentral gyrus on the right
- with a very small area of activation on the left during the speaking condition
Results

fMRI studies revealed that Patient #1 showed significant fMRI changes in a right-hemisphere network involving the premotor, inferior frontal, and temporal lobes, while Patient #2 had changes in a left-hemisphere network consisting of the inferior pre- and post-central gyrus and the superior temporal gyrus.
## Results

### TABLE 1

Summary of Language Outcomes.

<table>
<thead>
<tr>
<th>ID</th>
<th>Treatment</th>
<th>Measure</th>
<th>Baseline</th>
<th>Post40</th>
<th>% Change</th>
<th>Post75</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient 1</td>
<td>MIT</td>
<td>CIUs/min.</td>
<td>4.40</td>
<td>10.10</td>
<td>229.50</td>
<td>13.90</td>
<td>315.90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Syllables/phrase</td>
<td>1.80</td>
<td>4.10</td>
<td>227.80</td>
<td>4.70</td>
<td>261.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Picture naming (% correct)</td>
<td>60.00</td>
<td>80.00</td>
<td>133.30</td>
<td>95.00</td>
<td>158.30</td>
</tr>
<tr>
<td>Patient 2</td>
<td>SRT</td>
<td>CIUs/min.</td>
<td>3.60</td>
<td>6.80</td>
<td>188.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Syllables/phrase</td>
<td>2.40</td>
<td>4.00</td>
<td>166.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Picture naming (% correct)</td>
<td>59.00</td>
<td>72.00</td>
<td>122.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient 2</td>
<td>MIT (after SRT)</td>
<td>CIUs/min.</td>
<td>6.80</td>
<td>16.70</td>
<td>245.60</td>
<td>20.50</td>
<td>301.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Syllables/phrase</td>
<td>4.00</td>
<td>8.90</td>
<td>222.50</td>
<td>10.10</td>
<td>252.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Picture naming (% correct)</td>
<td>72.00</td>
<td>90.00</td>
<td>125.00</td>
<td>89.00</td>
<td>123.60</td>
</tr>
</tbody>
</table>

Note: MIT = Melodic Intonation Therapy; SRT = Speech Repetition Therapy; CIU/min = Correct Information Units/min; Picture naming = percent of correctly named pictures out of 60 (Boston Naming Test); Post40 refers to assessment after 40 treatment sessions; Post75 = after 75 treatment sessions.
Table 1

Patient #1's baseline and post40 fMRI studies (see Figure 3 in color plate section) showed posterior perisylvian activation on the left, and both superior temporal and inferior precentral gyrus activation on the right during the speaking condition (speaking vs. silence contrast); however, the post40 scan also showed more prominent right-hemispheric activation involving the right posterior middle premotor cortex and right inferior frontal gyrus, as well as a slightly smaller increase in activation of the posterior superior temporal gyrus.
Results

fMRI activation maps (superimposed onto the surface projections of a spatially standardized normal brain) of the contrast “Overt Speaking vs. Silence (control condition)” ($p < 0.05$ FWE) for Patients #1 and #2 at baseline and after 40 therapy sessions. The color coding reflects different magnitudes of activation: the color yellow reflects a stronger activation than the color red. Patient #2 also shows the “Overt Speaking vs. Silence (control condition)” contrast after an additional 40 sessions of MIT that followed the SRT sessions. Slight differences can be seen in the regional magnitude of activation with a greater magnitude of activation in the right premotor/motor and temporal lobes (yellow level of activation) and the slightly lower magnitude of activation in the left posterior perisylvian region (more red than yellow) comparing the images after MIT with the images after SRT treatment for Patient #2.
Discussion

L=spoken words  R+L=singing
Discussion

Bihemispheric? Left-hemispheric activation?

The representation of sensory elements of music and language might be either separate, or in different locations with smaller degrees of overlap.
If there is a bihemispheric representation for speech production, then the question of why an intervention that uses singing or a form of singing such as MIT has the potential to facilitate syllable and word production, still remains.
Discussion

In theory, there are four possible mechanisms by which MIT's facilitating effect may be achieved:

1. Reduction of speed
2. Syllable lengthening
3. Syllable “chunking”
4. Hand tapping
Discussion

How might melodic intonation influence recovery?
Discussion

Functional imaging tasks show greater activity in right-hemispheric brain regions than in left-hemispheric regions.

Patients with right-hemisphere lesions have greater difficulty with global processing (e.g., melody and contour processing) than those with left-hemisphere lesions.
Discussion

• the left hand tapping may serve the same function as a pacemaker or metronome

• left hand tapping are the unique elements of MIT that may likely be responsible for its therapeutic effect

• Elements of MIT that are shared with other, non-intonation-based therapies also have therapeutic effects, as can be seen in our patient treated with SRT.
Thank you!