Original Article

The Effectiveness of Addition of Melodic Intonation Therapy on Language Ability in Stroke Patients with Broca's Aphasia: A Pilot Randomized Controlled Trial

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ABSTRACT

Objectives: To evaluate the effectiveness of adding melodic intonation therapy (MIT) to conventional therapy in improving language abilities in Thai-speaking stroke patients with Broca's aphasia

Study design: A pilot randomized controlled trial

Setting: Three government hospitals in Thailand

Subjects: Eleven stroke survivors diagnosed with Broca's aphasia were enrolled in the study; eight completed the intervention and were analyzed.

Methods: Participants were randomly assigned to receive either conventional speech therapy or conven-tional therapy combined with MIT. Participants received three hours of therapy a week for eight weeks (two 30-minute sessions with a speech-language pathologist (SLP) and four 30-minute home-based sessions conducted by a caregiver). A blinded SLP assessed outcomes using the Thai adaptation of the Western Aphasia Battery (WAB) at baseline and three months post-baseline. Non-parametric tests (Wilcoxon Signed-Rank and Mann-Whitney U tests) were used due to the small sample size.

Results: The median age of participants was 56.5 years (IQR: 50.8-57.8) in the conventional group and 58.0 years (IQR: 33.5-67.5) in the conventional with MIT group. The median post-onset duration was longer in the conventional group (5.4 months, IQR: 2.4-9.8) compared to the MIT group (2.6 months, IQR: 1.0-4.6). Both groups showed improvements in fluency, comprehension, repetition, naming, and Aphasia Quotient (AQ). The MIT group demonstrated significantly greater gains in repetition and naming ($p < 0.05$).

Conclusions: The findings of this pilot study suggest that adding MIT to conventional therapy may enhance repetition and naming abilities in Thai-speaking individuals with Broca's aphasia. This finding supports the adaptation of MIT for tonal language contexts and highlights its potential in aphasia rehabilitation programs in Thailand. However, due to the limited sample size and statistical power, further research with larger samples is needed to confirm these findings.

Keywords: aphasia, speech therapy, stroke, rehabilitation

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Introduction

Stroke is a common condition worldwide. In 2021, stroke was the fourth leading cause of death globally.[1] In Thailand, according to a five-year report by the Department of Disease Control of the Ministry of Public Health, the number of stroke patients has steadily increased each year: from 2017 to 2021, the annual incidence of stroke per 100,000 population was 479, 534, 588, and 645, respectively. Similarly, the mortality rate per 100,000 population was recorded at 48, 47, 53, and 53, respectively. Additionally, approximately 30,000 people die from stroke annually, making it one of the leading causes of death in Thailand.[2] Stroke survivors often suffer from language and speech impairments, affecting approximately 4-20% of survivors.[3] Stroke-induced communication disorders are found in 15% of people under 65 years old and 43% of people over 85 years old.[4]

Patients with aphasia exhibit varying degrees of language and speech difficulties, depending on the location of brain damage, which impacts their daily communication. Aphasia can be classified into eight types: global aphasia, Broca's aphasia, isolation aphasia or transcortical mixed aphasia, transcortical motor aphasia, Wernicke's aphasia, transcortical sensory aphasia, conduction aphasia, and anomic aphasia.[5] Following a first stroke, the incidence rates of each type are as follows: global aphasia (32%), Broca's aphasia (12%), isolation aphasia (2%), transcortical motor aphasia (2%), Wernicke's aphasia (16%), transcortical sensory aphasia (7%), conduction aphasia (5%), and anomic aphasia (25%).[6] Broca's aphasia is caused by damage to the left hemisphere of the brain, with patients typically understanding speech well but struggling with word retrieval, sentence production, repetition, and sometimes reading and writing.[7,8]

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There are various methods of speech and language therapy (SLT) for patients with aphasia. These methods can be categorized based on the impairment: auditory comprehension SLT, word-finding SLT, repetition SLT, reading comprehension SLT, and writing SLT. Other approaches include functional SLT, phonological SLT, semantic SLT, constraint-induced aphasia therapy, multimodal therapy, conversational partner training SLT, and melodic intonation therapy (MIT).[9]

For patients with severe left hemisphere damage and non-fluent aphasia, traditional speech therapy alone often yields limited results because it depends on the impaired language network in the left hemisphere.[10] However, it has been reported that non-fluent aphasia patients can still sing,[11] leading to the development of MIT in 1973 by Albert et al.[12] MIT uses musical elements such as melody and rhythm to stimulate speech and improve communication, making it particularly beneficial for individuals with non-fluent aphasia, especially Broca's aphasia and apraxia of speech. MIT is a structured, hierarchical technique that begins with unison intoning of phrases and progresses to delayed repetition and spontaneous speech. Rhythmic left-hand tapping is used to support speech initiation through sensorimotor integration, leveraging preserved musical and prosodic abilities to enhance verbal output in individuals with severe non-fluent aphasia.[13,14]

Previous studies have shown that MIT is effective in tone-based languages such as Chinese,[15] suggesting its potential applicability to other tone-based Asian languages, including Thai. However, no prior studies have investigated the use of MIT in Thai individuals with aphasia. Therefore, the research team is interested in studying the effectiveness of adding MIT to conventional therapy in improving language abilities in patients with Broca's aphasia. The results will be used to develop a treatment model for hospitals across the nation.

Methods

Study design

This study is a randomized controlled trial (RCT) with a blinded outcome assessment, conducted in accordance with the CONSORT 2010 guidelines.[16]

The Human Research Ethics Committee of Sirindhorn National Medical Rehabilitation Institute (SNMRI) on December 23, 2020, Lampang Cancer Hospital (on behalf of Vejjarak Lampang Hospital or VJLH) on February 18, 2021, and Neurological Institute of Thailand (NIT) approved this study under approval numbers 64001, 40/2564-27/2666, and 031/2564 (project number 64016) on July 18, 2021, respectively. Informed consent was obtained from all participants. This study was registered with the Thai Clinical Trials Registry (TCTR20250411008). As participant recruitment did not progress as anticipated and the funding period concluded, the study was discontinued before reaching the intended sample size. All relevant IRBs were formally notified. Given the small number of enrolled participants and the discontinuation of recruitment, the study was conducted as a pilot trial to explore feasibility and inform the design of future larger-scale randomized trials.

Participants

The sample size calculation used the n4Studies application, employing the formula for testing two independent means (two-tailed test),[17] with the Aphasia Quotient (AQ) as the primary outcome variable. Estimates were based on previous studies reporting a mean of 18.7 (SD = 13.6) in group 1 and 6.1 (SD = 9.2) in group 2.[18] with an alpha of 0.05 and a beta of 0.20, the calculated sample size was 14 participants per group, increased by 5% to account for potential dropouts, for a total of 30 participants.

Inclusion criteria

1. First-time stroke confirmed by neuroimaging (CT or MRI).
2. Aged 20-70 years, with Thai as their primary language, and at least 6 years of education (starting from Year 1 of primary school) to reduce potential confounding from dementia and low educational level.[19]
3. SLP diagnosed Broca's aphasia using the Thai adaptation of the Western Aphasia Battery (WAB), based on an AQ of less than 94.7[20] and the following subtest score ranges: fluency 0-4, comprehension 4-10, repetition 0-7.9, naming 0-8.[21]
4. Able to cooperate during therapy without emotional disturbances affecting participation.[22]
5. Has a committed Thai caregiver, aged 20-60 years, who is literate and can assist with home practice for at least 30 minutes, four days a week, over eight weeks.[23]

Exclusion criteria

1. Presence of right hemisphere brain pathology as determined by CT or MRI.[24]
2. Presence of visual or hearing impairments affecting assessment and therapy, as determined from patient and caregiver history, since these sensory limitations could interfere with participants' ability to accurately perceive and respond to test stimuli, potentially confounding the results.
3. Patients receiving speech therapy at other hospitals during the study.
4. Presence of medical conditions such as heart disease, epilepsy, or dementia.
5. Inability to maintain the prescribed frequency or duration of home practice or failure to follow therapy instructions provided by the SLP.

Randomization

Randomization was conducted using a mixed-size block method. An independent SLP not involved in the study generated the allocation sequence using Microsoft Excel. The personnel responsible for enrolling participants and assigning them to intervention groups had no access to the allocation sequence. Assignments were sealed in opaque envelopes to ensure allocation concealment. Participants were randomly assigned to the control or experimental group in a 1:1 ratio.

Intervention

Participants were randomly assigned to one of two groups: a conventional speech therapy group and a conventional therapy group combined with the MIT approach. Patients received eight weeks of treatment, comprising two sessions/week with SLP (30 minutes each) and four sessions/week at home with a caregiver (30 minutes each), totaling 3 hours per week.[23] Caregivers were instructed to support participants in continuing the activities practiced during in-clinic training and to document each home-based training session in a daily logbook. These records were used to verify participant adherence and monitor the fidelity of the intervention conducted at home. SLPs also used logbooks to document each therapy session conducted at the hospital, supporting fidelity monitoring across sites. Due to the nature of the intervention, blinding patients, caregivers, and SLPs delivering therapy was not feasible. No concomitant speech or language interventions were provided during the study period. No interim analyses or stopping guidelines were planned. A preparatory meeting and training session were held onsite with research teams from the three participating sites. Expert SLPs provided training and guidance on the implementation of the MIT technique. While the total therapy time was equal between groups, the strategies used to support speech production differed, consistent with the principles of each intervention.

Melodic intonation therapy (MIT)

Procedures for implementing MIT were based on established guidelines from Helm-Estabrooks et al. and Norton et al.[13,14] The therapy was designed for individuals with non-fluent aphasia and consisted of three hierarchical levels: elementary, intermediate, and advanced, progressing from two-syllable words to longer phrases. Each level included approximately 20 high-probability words or commonly used social phrases, presented with visual cues to support speech production. Phrases were intoned using two pitch levels based on natural prosody, with stressed syllables produced at a higher pitch and unstressed syllables at a lower pitch. Patients tapped their left hand once per syllable during intonation to support rhythm and motor planning. At each level, structured steps were followed, including humming, unison intoning, delayed repetition, and response to probe questions (e.g., “What did you say?”), with cueing gradually reduced. In later stages, speech-like intonation (Sprechgesang) was introduced and transitioned toward natural speech. Throughout all levels, activities and cueing strategies were adapted to match each individual’s abilities and progress.

Conventional speech therapy

For conventional treatment, procedures followed the Guidelines for Assessment and Diagnosis of Disabilities under the Ministry of Social Development and Human Security.[25] The treatment aimed to improve basic communication skills, comprehension, and cognitive functions in individuals with Broca’s aphasia. The intervention included communication and language-focused training, such as basic communication to express needs, auditory comprehension of words and conversations, and lexical retrieval of common items used in daily life. Cognitive stimulation targeted time, place, and person orientation, as well as memory, reasoning, and social interaction skills. Speech and articulation components included oral motor exercises to strengthen the speech organs, coordination training to improve articulator function, breathing exercises for voice control, and practice in producing vowels and simple words, as well as articulating consonants, vowels, and tones to enhance clarity and phonological accuracy. In addition, reading and writing tasks were simplified to match the patient’s ability, and alternative communication strategies, such as picture-based tools, were introduced to support effective communication when verbal output was limited.[25]

Cueing protocol for conventional group

The conventional therapy group followed an additional cueing protocol to support participants in articulating target words. If a participant was unable to produce the target word within five seconds, the therapist provided a cue selected from the following types: (1) verbal associations, (2) written cues, (3) description of use, context of use, or function, (4) description of form, position in space, or outward characteristics, (5) gesture of action or function, (6) gesture of shape, location, or outward characteristics, (7) spelling or letter cues, and (8) production of the sound made by the object. The selection of cues depended on the nature of each target word, and therapists could combine two types of cues if a single method were insufficient. If the patient remained unable to respond within five seconds after cueing, the therapist then provided the initial sound of the word. If still unsuccessful after an additional five seconds, the initial syllable was given. Finally, if the patient continued to experience difficulty, the therapist produced the complete target word and prompted the patient to repeat it.[26,27] This cueing protocol was used only in the conventional group. It was not applied in the conventional manner with the MIT group, where target words were presented exclusively through structured MIT procedures.

Outcome measurements

SLPs conducted baseline assessments for participant eligibility at each site. Outcome assessments were conducted three months post-baseline by a blinded assessor who was not involved in the intervention. This SLP assessed participants onsite at one site and scored the others via video recordings.

The Thai adaptation of the Western Aphasia Battery (WAB)[20] was used as the primary outcome measure to assess language abilities in individuals with aphasia. This standardized tool quantifies severity and classifies aphasia subtypes based on four core domains: spontaneous speech, auditory comprehension, repetition, and naming. The resulting AQ ranges from 0 to 100, with higher scores indicating better performance. The Thai version demonstrated strong content validity and excellent test-retest reliability ($r = 0.99$, $p < 0.01$), with an AQ cutoff of 94.7.[20]. Subtypes are classified using domain-specific cutoffs into eight standard types: Global, Broca's, Wernicke's, Conduction, Transcortical Motor, Transcortical Sensory, Isolation, and Anomic.[21] These criteria enable consistent classification, longitudinal tracking, and cross-linguistic comparisons, as the WAB has been widely translated and used internationally.[28]

While participants and the treating researchers were not blinded, the assessors were blinded to the treatment groups. The study employed a parallel-group design under a superiority framework to evaluate the effectiveness of adding Melodic Intonation Therapy to conventional therapy. Patients and members of the public were not involved in this research's design, conduct, reporting, or dissemination plans.

Statistical methods

Statistical analysis was performed using IBM SPSS Statistics for Mac, version 26.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to report demographic information. The effectiveness of the intervention was assessed by comparing pre- and post-treatment results within each group and by comparing change scores between groups, using non-parametric tests (Wilcoxon Signed-Rank test, Mann-Whitney U test), based on data normality test results and the small sample size. All analyses were pre-specified in the study protocol based on participants who completed both baseline and post-treatment assessments. Participants who withdrew before completing the intervention and post-assessment were excluded from the analysis. No imputation for missing data, subgroup or sensitivity analyses, or ancillary analyses were conducted.

Results

Recruitment challenges limited the final sample size. Although 30 participants were initially planned, only 11 were enrolled, and eight were analyzed by per-protocol. The COVID-19 pandemic hindered recruitment, limited the number of eligible Broca's aphasia cases, and led to caregiver unavailability, staff constraints, and logistical barriers. As a result, the study proceeded as a pilot trial to assess feasibility.

This study includes data from 8 participants: seven from SNMRI and one from VJLH. No participants from NIT met the inclusion criteria. Participants were randomly assigned to the conventional therapy group (n = 4) or the conventional therapy combined with MIT group (n = 4). Participant flow reported following CONSORT guideline 2010[29], is shown in Figure 1.

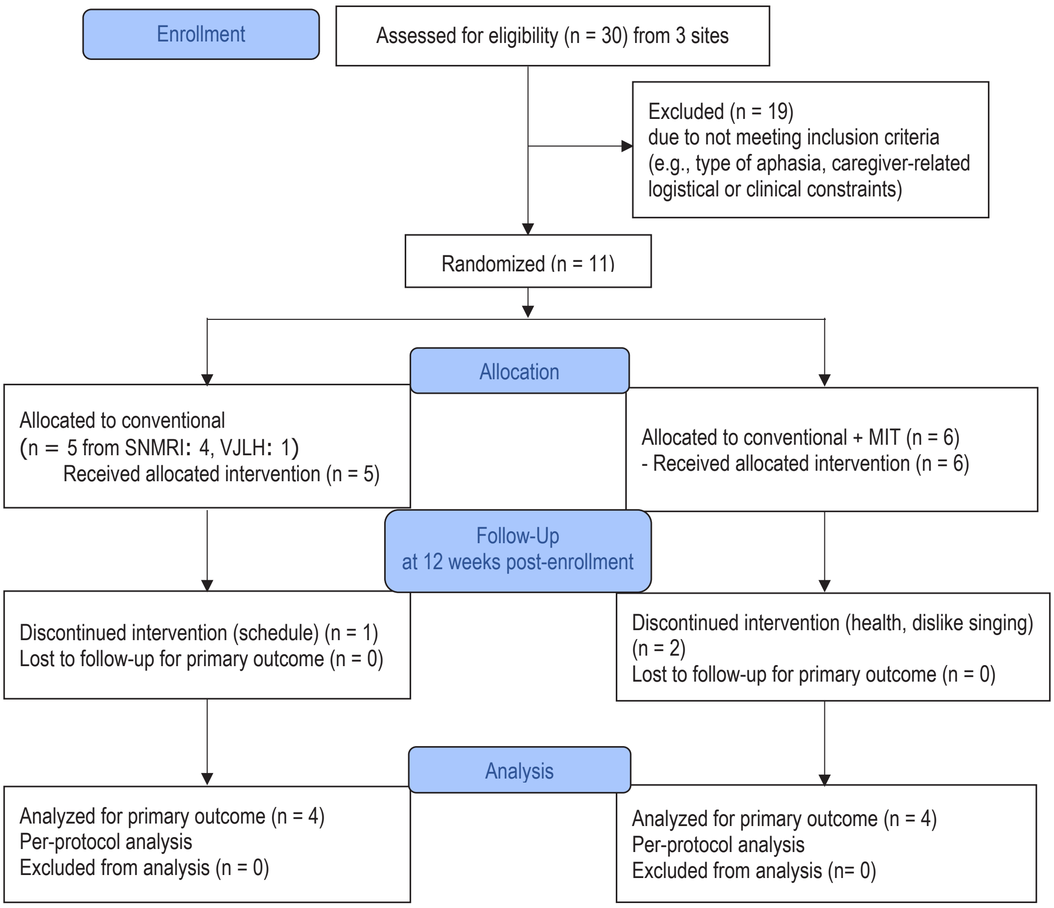

Figure 1. Participant flow diagram following CONSORT guidelines[29]

Normality of the data was assessed using the Shapiro-Wilk test due to the small sample size (n = 8). Several variables violated the assumption of normality, including years of education (p = 0.016), fluency change score (p = 0.013), baseline comprehension (p = 0.049), and post-treatment AQ (p = 0.030). As a result, non-parametric tests were employed for all subsequent within- and between-group comparisons.

The baseline demographic and clinical characteristics of the participants are presented in Table 1. The proportion of female participants was higher in the conventional with MIT group compared to the conventional group (83% vs. 60%), as was the proportion of participants with hemorrhagic stroke (50% vs. 40%). The median age of participants was 56.0 years (IQR: 48.5-57.5) in the conventional group and 57.5 years (IQR: 38.5-66.5) in the conventional with MIT group. The median years of education was higher in the conventional with MIT group (16.0 vs. 14.0 years). The median post-onset duration was longer in the conventional group (4.1 months, IQR: 1.1-8.7) than in the conventional with MIT group (2.4 months, IQR: 1.0-3.8). Baseline scores for fluency, comprehension, repetition, naming, and AQ were generally comparable between groups. Three participants who later withdrew had lower baseline scores and a shorter post-onset duration.

Between-group comparisons of baseline, post-treatment, and change scores were conducted using the Mann-Whitney U test with Monte Carlo simulation (Table 2), revealing no statistically significant differences between the conventional and conventional with MIT groups (p > 0.050), indicating baseline equivalence. Following treatment, the conventional with MIT group showed significantly greater improvement in repetition (p = 0.026, r = 0.837) and naming (p = 0.024, r = 0.816) compared to the conventional group. While both groups demonstrated improvements in other language domains and AQ scores, between-group differences in fluency, comprehension, and AQ change scores were not statistically significant.

Table 1. Baseline demographic and clinical characteristics of patients

Characteristics	Conventional (n = 5)	Conventional plus MIT (n = 6)
Gender		
Females (%)	3 (60)	5 (83)
Type of stroke		
Hemorrhage	2	3
Ischemic	3	3
Age (years)	56.0 (48.5, 57.5)	57.5 (38.5, 66.5)
Education (years)	14.0 (10.5, 16.0)	16.0 (8.3, 16.0)
Post-onset (months)	4.1 (1.1, 8.7)	2.4 (1.0, 3.8)
Fluency	2.0 (1.0, 2.5)	2.5 (0.8, 3.3)
Comprehension	4.9 (4.5, 6.4)	5.0 (4.4, 5.7)
Repetition	3.2 (2.0, 3.9)	3.1 (0.0, 5.1)
Naming	2.5 (1.7, 2.8)	0.3 (0.0, 2.3)
Aphasia quotient (AQ)	28.8 (27.7, 34.9)	26.2 (14.7, 36.7)

Values are presented as median (interquartile range). Education level (in years) is calculated starting from Year 1 of primary school

Table 2. Between-group comparison of baseline, post-treatment, and change scores in the conventional and conventional with MIT Groups

	Conventional (n = 4)	Conventional+MIT (n = 4)	p-value	Effect sizes
Fluency				
Baseline	2.0 (1.3, 2.8)	3.0 (0.8, 3.8)	0.515	-0.316
Post-treatment	3.0 (2.3, 4.5)	4.5 (3.3, 8.0)	0.285	-0.474
Change score (Δ)	1.0(1.0, 1.8)	3.0 (0.3, 5.0)	0.763	-0.164
Comprehension				
Baseline	4.9 (4.5, 7.0)	5.1 (4.5, 6.2)	0.973	-0.051
Post-treatment	7.1 (5.5, 8.5)	6.2 (5.5, 8.9)	1.000	0.000
Change score (Δ)	1.5 (0.4, 2.9)	0.6 (0.2, 3.9)	0.882	-0.102
Repetition				
Baseline	3.2 (1.7, 3.9)	4.5 (1.1, 6.1)	0.338	-0.408
Post-treatment	4.2 (3.5, 5.7)	7.6 (4.3, 9.3)	0.201	-0.510
Change score (Δ)	2.0 (0.6, 2.0)	3.3 (2.4, 3.8)	0.026*	-0.837
Naming				
Baseline	2.1 (1.6, 2.7)	0.9 (0.0, 3.4)	0.514	-0.258
Post-treatment	3.2 (1.9, 4.8)	6.0 (3.6, 8.0)	0.114	-0.612
Change score (Δ)	1.1 (0.2, 2.1)	4.1 (3.2, 6.1)	0.024*	-0.816
Aphasia quotient (AQ)				
Baseline	31.2 (28.0, 35.5)	31.6 (14.0, 42.0)	0.882	-0.102
Post-treatment	45.9 (36.3, 52.9)	53.3 (50.5, 82.2)	0.114	-0.612
Change score (Δ)	15.3 (7.0, 18.2)	34.3 (17.7, 46.4)	0.114	-0.612

Values are presented as median (interquartile range). P-values refer to between-group comparisons using the Mann-Whitney U Test with a Monte Carlo simulation.[30] Effect size (r) was calculated from Z scores using the formula r = Z/√N, where N is the total sample size[31] (0.2: small, 0.5: medium, 0.8 = large).[32] *p-values less than 0.05 were considered statistically significant

Table 3. Within group comparison of language outcomes at baseline and post-treatment in the conventional and conventional with MIT groups

	Baseline	Post-treatment	Change (Δ)	*p*-value	Effect sizes
Fluency					
Conventional (n = 4)	2.0 (1.3, 2.8)	3.0 (2.3, 4.5)	1.0 (1.0, 1.8)	0.127	-0.945
Conventional plus MIT (n = 4)	3.0 (0.8, 3.8)	4.5 (3.3, 8.0)	3.0 (0.3, 5.0)	0.249	-0.817
Comprehension					
Conventional (n=4)	4.9 (4.5, 7.0)	7.1 (5.5, 8.5)	1.5 (0.4, 2.9)	0.126	-0.913
Conventional plus MIT (n = 4)	5.1 (4.5, 6.2)	6.2 (5.5, 8.9)	0.6 (0.2, 3.9)	0.124	-0.913
Repetition					
Conventional (n=4)	3.2 (1.7, 3.9)	4.2 (3.5, 5.7)	2.0 (0.6, 2.0)	0.126	-0.945
Conventional plus MIT (n = 4)	4.5 (1.1, 6.1)	7.6 (4.3, 9.3)	3.3 (2.4, 3.8)	0.124	-0.913
Naming					
Conventional (n=4)	2.1 (1.6, 2.7)	3.2 (1.9, 4.8)	1.1 (0.2, 2.1)	0.126	-0.913
Conventional plus MIT (n = 4)	0.9 (0.0, 3.4)	6.0 (3.6, 8.0)	4.1 (3.2, 6.1)	0.124	-0.913
Aphasia quotient (AQ)					
Conventional (n=4)	31.2 (28.0, 35.5)	45.9 (36.3, 52.9)	15.3 (7.0, 18.2)	0.126	-0.913
Conventional plus MIT (n = 4)	31.6 (14.0, 42.0)	53.3 (50.5, 82.2)	34.3 (17.7, 46.4)	0.124	-0.913

Values are presented as median (interquartile range). *p*-values refer to within-group comparisons using the Wilcoxon Signed-Rank test with a Monte Carlo simulation.[30] Effect size (*r*) was calculated from Z scores using the formula $r = Z/\sqrt{N}$, where N is the total number of observations[31] (0.2 = small, 0.5 = medium, 0.8 = large).[32] *Statistical significance was set at $p < .05$.

Within-group comparisons of baseline and post-treatment were conducted using the Wilcoxon Signed-Rank test with a Monte Carlo simulation, as presented in Table 3. Both the conventional and the conventional with MIT groups showed improvements across all language domains. However, none of the within-group differences reached statistical significance ($p > 0.05$), possibly due to the small sample size (n = 4 per group).

Despite this, Table 3 shows that large effect sizes were observed in both groups. In the conventional with MIT group, effect sizes were slightly smaller for fluency ($r = 0.817$) and repetition ($r = 0.913$) compared to the conventional group ($r = 0.945$ for both outcomes). For other outcomes, the effect sizes were equal ($r = 0.913$ in both groups).

A post hoc power analysis was conducted using G*Power 3.1 for Mac (Heinrich Heine University, Düsseldorf, Germany) for the Wilcoxon-Mann-Whitney test. Based on the observed effect sizes of change scores in repetition ($r = 0.837$) and naming ($r = 0.816$) from the between-group comparison, with a sample size of 4 participants per group and a significance level of $\alpha = 0.05$ (two-tailed), the calculated statistical power was approximately 0.16. This low power may have contributed to the lack of statistically significant findings, despite the large observed effect sizes.

No harm or adverse events were monitored or observed during the trial.

Discussion

This pilot study found that adding MIT to conventional speech therapy led to greater improvements in repetition and naming abilities in Thai individuals with Broca's aphasia compared to conventional therapy alone. Although both groups showed progress in fluency, comprehension, repetition, and naming, statistically significant differences were observed specifically in repetition and naming. These findings suggest that MIT may be particularly beneficial in addressing specific language deficits commonly observed in non-fluent aphasia, such as difficulties with word retrieval and repetition.

Previous observations by SLPs indicate that patients with severe aphasia often demonstrate better articulatory muscle movement while singing compared to normal speech. This observation has led to the incorporation of music and singing into aphasia rehabilitation.[33] In 1973, Albert, Sparks, and Helm introduced MIT, a treatment that combines melody, rhythm, and speech to enhance articulation. The therapy follows a structured process, starting with patients singing simple phrases to a melody and gradually progressing to speaking without musical cues.[12] However, the majority of MIT literature comprises RCT studies focused on Western languages, with fewer studies examining East Asian languages such as Japanese and Chinese. Unlike Western languages, many East Asian languages, including Thai, are tonal, where differences in tone convey distinct meanings, necessitating more complex neural processing involving bilateral brain circuits.[34,35] A recent pilot study by Chen et al.[15] adapted MIT into a tone-rhythmic therapy (TRT) specifically for Mandarin, incorporating lexical tones and rhythmic patterns characteristic of the language. Six individuals with non-fluent aphasia, more than six months post-stroke, received TRT over six weeks, with five 50-minute sessions per week. Results showed improvements in speech and language skills that were sustained for up to six months. These findings highlight the potential of MIT-based approaches in tonal languages. While no adaptation was made, the present study applied MIT in a Thai-speaking population, another tonal language, providing foundational evidence for its feasibility and therapeutic benefit in this linguistic context.

Difficulty in recruitment for this study

The study aimed to recruit 30 patients across multiple sites but was able to enroll only 8 participants due to limited resources. Contributing factors included patients not meeting the inclusion criteria, a higher prevalence of global aphasia compared to Broca's aphasia, and reduced availability due to the COVID-19 pandemic. Emotional factors, including frustration and depression, also contributed to participant recruitment challenges or withdrawal, with depression rates as high as 40-60% among stroke survivors with aphasia.[36,37] Several patients withdrew due to health issues or discomfort with MIT training, and some caregivers did not meet the inclusion criteria. Additional barriers included travel, financial limitations, and staffing constraints, which impacted participation and follow-up opportunities.

Conducting research with aphasia patients in Thailand presented significant challenges, as the pool of eligible participants is smaller due to limited access to speech therapy services, further compounded by the pandemic. Caregiver involvement also proved challenging, as many struggled to commit to the at-home training. Some caregivers may not have been able to manage the demands of high-intensity therapy.[38] Caregivers frequently had to prioritize advocating for timely care and ensuring patient engagement in rehabilitation; balancing these responsibilities can be overwhelming.[39] Some caregivers believed that therapy should focus on the patient receiving treatment rather than on them receiving training.[40] These challenges suggest the need for hybrid teletherapy models when patients cannot attend sessions. Teletherapy can help address common barriers, including distance, travel costs, and time constraints.[41]

Expanding the inclusion criteria to encompass broader non-fluent aphasia may also increase the pool of eligible patients, as MIT has shown effectiveness in this condition.[35,42,43] In this study, only patients with Broca's aphasia were included to reduce heterogeneity in language profiles. However, as WAB does not detect apraxia of speech, which may co-occur with Broca's aphasia[44] and also benefits from MIT,[14,45] future studies should identify this subgroup to avoid potential bias.

Improvement of participants

Post-intervention WAB scores indicated significant improvements across all four subtests in both groups, consistent with the findings of Hough (2010), who implemented 3 hours of therapy per week over eight weeks[23], and Robey (1998), who reported that at least 2 hours per week yielded improvements.[46] Previous systematic reviews have raised unresolved questions regarding the optimal timing for starting MIT, particularly whether it should be initiated in the acute or chronic phase. The timing of therapy is closely linked to neural recovery and may result in different outcomes.[47] In this study, both groups had post-onset periods within six months, corresponding to the subacute or intermediate care phase. Notably, the conventional group with the MIT group had a shorter post-onset duration (median = 2.4 months, IQR: 1.0-3.8) compared to the conventional group (median = 4.1 months, IQR: 1.1-8.7). This difference may have favored treatment responsiveness in the MIT group due to spontaneous recovery, potentially confounding the results for some patients.[48] Future studies should match participants by post-onset time or include it as a covariate.

When comparing the groups, statistically significant improvements ($p < 0.05$) were observed in repetition and naming abilities in the experimental group compared to the control group. However, no significant differences were found in fluency or comprehension scores. This result is consistent with Lim et al. (2013), who found that adding MIT significantly improved verbal repetition and word retrieval.[18] Furthermore, systematic reviews[35,42] and meta-analysis[43,49] by Popescu, Haro-Martinez, and others have confirmed that MIT has the most potent effects on repetition tasks.

MIT is particularly beneficial for patients with left hemisphere damage who retain the right hemisphere's capacity for music. By activating the right hemisphere's auditory cortex for music processing and the right hemisphere's language motor areas, which correspond to the left hemisphere's Broca's area via the right arcuate fasciculus, MIT compensates for damaged areas and facilitates language output.[50] Degeneracy,[51] or the reorganization of language functions to the contralateral hemisphere, has also been observed in patients with brain tumors near Wernicke's area.[52] All participants in this study had left hemisphere brain damage, with an intact right hemisphere, making them well-suited for MIT. Other hypotheses explain why MIT is effective in treating non-fluent aphasia: MIT slows the rate of speech,[53] it prolongs the duration of syllables and introduces pauses between them,[24] and it incorporates left-hand tapping for each syllable, activating the right hemisphere, which controls both speech-related and arm movements,[54] all of which contribute to its success, particularly in enhancing the repetition and naming abilities observed in this study.

MIT is unsuitable for patients whose primary deficit is comprehension, such as those with Wernicke's aphasia, transcortical aphasia, conduction aphasia, or brain injuries affecting language comprehension.[22] In this study, both the control and experimental groups demonstrated significant improvements in comprehension, but no statistically significant differences were found between them. This result may be due to MIT's primary focus on enhancing expressive language. However, Morrow-Odom and Swann (2013) reported the effectiveness of MIT in a single case of global aphasia, where the patient received 2.5 hours of therapy per day, five days a week, for seven consecutive weeks. Post-therapy, the patient showed improvement in auditory comprehension, repetition, and sentence length, suggesting that MIT could also benefit global aphasia rehabilitation.[55] The lack of significant differences in fluency scores between the control and experimental groups in this study may be attributed to the fact that most patients in both groups were still practicing at the word level, limiting gains in speech fluency.

In addition to statistical significance, improvements observed in the conventional group with the MIT group surpassed the minimal clinically important differences (MCID) as defined by Katz and Wertz.[56] Specifically, an increase of at least 5 points on the WAB AQ and at least 1 point on WAB subtests was considered clinically significant. Although the MIT group showed clinically significant gains in fluency, repetition, naming, and AQ, the improvement in auditory comprehension was smaller than in the conventional group. The median change in comprehension for the MIT group was only 0.6 points, falling below the 1-point MCID threshold. This change suggests that MIT, which primarily targets expressive language, may have limited effects on receptive abilities. These findings underscore the need for combined or tailored approaches and should be interpreted with caution, especially given the small sample size.

Treatment adherence

Although one participant in the conventional group discontinued due to scheduling difficulties, two participants in the experimental group also withdrew: one due to health issues requiring treatment at another hospital, and the other due to discomfort with singing. Despite these withdrawals, both patients and caregivers in both groups demonstrated excellent adherence to the therapy and home practice programs. This strong adherence contributed to statistically significant improvements in all domains of speech and language in both the control and experimental groups. The therapy program, comprising one hour of therapy with an SLP and two hours of home practice per week (a total of three hours weekly) over eight consecutive weeks, proved effective for all participants.

Applicability of MIT in the Thai context

In addition to the patient's preserved right hemisphere abilities, the successful application of MIT depends on the interest and comfort of the SLPs, patients, and caregivers in using melodic intonation and singing. SLPs must be trained in the technique, prepare target words, phrases, and sentences in advance, and be capable of teaching patients and, importantly, their caregivers how to practice MIT at home. Additionally, SLPs should carefully consider the meaning of words when sung, as tonal changes in the melody may confuse due to the tonal nature of the Thai language.

A post hoc power analysis indicated a statistical power of approximately 0.16 for detecting differences in repetition and naming scores between groups. This low power, due to the small sample size (n = 4 per group), suggests a risk of type II error, meaning that true effects may exist but were not detected. Therefore, the findings should be interpreted with caution, and future studies with larger sample sizes are warranted.

This feasibility study provides preliminary evidence supporting the benefit of adding MIT for Thai individuals with Broca's aphasia on repetition and naming abilities by engaging preserved right hemisphere functions. The limitations of this pilot study should also be noted. In addition to the small sample size, the exclusive inclusion of individuals with Broca's aphasia limits the generalizability of the findings. Therapy intensity was restricted to 3 hours per week,[18] comprising 1 hour provided by an SLP and 2 hours by caregivers, due to constraints of the existing service model, where typically only 30 minutes per week of professional therapy is available. Additionally, to minimize bias, a blinded SLP reviewed recorded sessions from the site where only one therapist provided treatment.

Future research should evaluate the effectiveness of MIT in other forms of non-fluent aphasia and apraxia of speech. Stratifying participants according to post-stroke onset phase (subacute vs. chronic)[47] could further clarify how timing affects recovery outcomes. Addressing these limitations through larger-scale studies would strengthen understanding of MIT's clinical utility across diverse patient populations.

Conclusions

This study found that both the experimental and control groups showed significant improvements in language and speech abilities, with the group receiving MIT alongside standard therapy demonstrating greater gains in verbal repetition and word retrieval ($p < 0.05$). As a pilot study, these findings are promising additions to speech-language rehabilitation in Thailand, but should be interpreted with caution and validated in larger-scale research.

Conflict of interest declaration

The authors declare that there is no conflict of interest.

Generative AI declaration

The authors confirm that no large language models (LLMs) or artificial intelligence (AI) tools were used in the creation of this manuscript, including the writing, editing, or preparation of figures and tables, with the exception of Grammarly for basic spell-checking.

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Data availability

The data supporting the findings of this study are available upon request from the corresponding author, Nicha Kripanan. The data are not publicly available due to ethical restrictions and the need to protect the privacy of research participants.

Author contributions

Somjit Ruamsuk: project administration, conceptualization, funding acquisition, resources, supervision, methodology, validation, writing-original draft preparation,

Nicha Kripanan: investigation, writing-original draft preparation, data curation, formal analysis, visualization,

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Jiratchaya Pinudom: investigation, writing-review & editing,

Nattawut Foopong: investigation, writing-review & editing,

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References

1. World Health Organization. The top 10 causes of death [Internet]. 2021 [cited 2024 Feb 1]. Available from: https://www.who.int/news-room/fact-sheets/detail/the-top-10-causes-of-death
2. Department of Disease Control, Ministry of Public Health. Stroke awareness campaign for World Stroke Day 2021: "Recognize the warning signs of stroke, every second counts" [Internet]. 2021 Oct 28 [cited 2024 Feb 1]. Available from: https://ddc.moph.go.th/brc/news.php?news=29284&deptcode=
3. Jariengprasert C. Speech therapy in cerebrovascular disease patient with communication problems. Vichaiyut Newsletter. 2005 [cited 2020 June 17].
4. Engelter ST, Gostynski M, Papa S, Frei M, Born C, Ajdacic-Gross V, et al. Epidemiology of aphasia attributable to first ischemic stroke: incidence, severity, fluency, etiology, and thrombolysis. Stroke. 2006 Jun [cited 2020 June 17];37(6):1379-84. doi: 10.1161/01.STR.0000221815.64093.8c. Epub 2006 May 11. PMID: 16690899
5. Ruamsuk S, Ngamsri A. The study of speech and language scores of Thai adaptation of Western Aphasia Battery in normal Thai participants aged 15-24 years old. J Dep Med Serv. 2015:40;66-79.
6. Pedersen PM, Vinter K, Olsen TS. Aphasia after stroke: type, severity and prognosis. The Copenhagen aphasia study. Cerebrovasc Dis. 2004 [cited 2020 June 17];17(1):35-43. doi: 10.1159/000073896. Epub 2003 Oct 3. PMID: 14530636.
7. Kelly H, Brady MC, Enderby P. Speech and language therapy for aphasia following stroke. Cochrane Database Syst Rev. 2010 May [cited 2020 June 17];(5):CD000425. doi: 10.1002/14651858.cd000425.pub2. PMID: 20464716.
8. Hillis AE. The 'standard' for poststroke aphasia recovery. Stroke. 2010 Jul[cited 2020 June 17];41(7):1316-7. doi: 10.1161/STROKEAHA.110.585364. Epub 2010 Jun 10. PMID: 20538691.
9. Brady M, Ali M, Vandenberg K, Williams L, Williams L, Abo M, et al. RELEASE: a protocol for a systematic review based, individual participant data, meta-and network meta-analysis, of complex speech-language therapy interventions for stroke-related aphasia. Aphasiology. 2020 Feb [cited 2020 June 17];34(2):137-157. doi: 10.1080/02687038.2019.1643003. PMID: 37560459; PMCID: PMC7614912.
10. Berthier ML, Pulvermüller F. Neuroscience insights improve neurorehabilitation of poststroke aphasia. Nat Rev Neurol. 2011 Feb [cited 2020 June 17];7(2):86-97. doi: 10.1038/nrneurol.2010.201. PMID: 21297651.
11. Marini A, Caltagirone C, Pasqualetti P, Carlomagno S. Patterns of language improvement in adults with non-chronic non-fluent aphasia after specific therapies. Aphasiology. 2007 [cited 2020 June 17];21(2):164-86. doi:10.1080/02687030600633799.
12. Albert ML, Sparks RW, Helm NA. Melodic intonation therapy for aphasia. Arch Neurol. 1973 Aug [cited 2020 June 17];29(2):130-1. doi: 10.1001/archneur.1973.00490260074018. PMID: 4717723.
13. Helm-Estabrooks N, Nicholas M, Morgan A. Melodic Intonation Therapy program. Austin, TX: PRO-ED Publishers; 1989.
14. Norton A, Zipse L, Marchina S, Schlaug G. Melodic intonation therapy: shared insights on how it is done and why it might help. Ann N Y Acad Sci. 2009 Jul [cited 2020 June 17];1169:431-6. doi: 10.1111/j.1749-6632.2009.04859.x. PMID: 19673819; PMCID: PMC2780359.
15. Chen W, Qian Q, van de Weijer J, Zhu S, Wang M. Adaptation of Melodic Intonation Therapy to a Tone Language: A Pilot Study of Tone-Rhythmic Therapy in Mandarin Chinese. Folia Phoniatr Logop. 2023 [cited 2024 Feb 1];75(2):104-116. doi: 10.1159/000527225. Epub 2022 Sep 27. PMID: 36167033.
16. Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG; CONSORT. CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. Int J Surg. 2012 [cited 2025 June 10];10(1):28-55. doi: 10.1016/j.ijsu.2011.10.001. Epub 2011 Oct 12. PMID: 22036893.
17. Ngamjarus C. n4Studies: Sample size calculation for an epidemiological study on a smart device. Siriraj Med J. 2016 [cited 2020 June 17];68(3):160-70.
18. Lim KB, Kim YK, Lee HJ, Yoo J, Hwang JY, Kim JA, Kim SK. The therapeutic effect of neurologic music therapy and speech language therapy in post-stroke aphasic patients. Ann Rehabil Med. 2013 Aug [cited 2020 June 17];37(4):556-62. doi: 10.5535/arm.2013.37.4.556. Epub 2013 Aug 26. PMID: 24020037; PMCID: PMC3764351.
19. The Committee Prepared the Preliminary Brain Test-Thai version. Mini Mental Examination Thai-2002 (MMSE-2002) [in Thai]. Nonthaburi: Institute of Geriatric Medicine, Department of Medical Services, Ministry of Public Health; 2002.
20. Teerapong W. The comparison of language abilities of Thai aphasic patients and Thai normal subjects by using Thai adaptation of Western Aphasia Battery [thesis]. Mahidol University; 2000.

21. Kertesz A, Poole E. The aphasia quotient: the taxonomic approach to measurement of aphasic disability. 1974. Can J Neurol Sci. 2004 May [cited 2020 June 17];31(2):175-84. doi: 10.1017/s0317167100120736. PMID: 15198441.
22. Helm-Estabrooks N, Albert M. Manual of aphasia and aphasia therapy. Austin, TX: PRO-ED Publishers; 2004.
23. Hough MS. Melodic intonation therapy and aphasia: another variation on a theme. Aphasiology. 2010 [cited 2020 June 17];24(6-8):775-86. doi:10.1080/02687030903501941.
24. Schlaug G, Marchina S, Norton A. From Singing to Speaking: Why Singing May Lead to Recovery of Expressive Language Function in Patients with Broca's Aphasia. Music Percept. 2008 Apr 1[cited 2020 June 17];25(4):315-323. doi: 10.1525/MP.2008.25.4.315. PMID: 21197418; PMCID: PMC3010734.
25. Sirindhorn National Medical Rehabilitation Institute. Guidelines for assessment and diagnosis of disabilities. Nonthaburi: Ministry of Social Development and Human Security; 2012.
26. Tompkins CA, Scharp VL, Marshall RC. Communicative value of self cues in aphasia: A re-evaluation. Aphasiology. 2006 Jul 1 [cited 2020 June 17];20(7):684-704. doi: 10.1080/02687030500334076. PMID: 20090926; PMCID: PMC2808031.
27. Best W, Greenwood A, Grassly J, Herbert R, Hickin J, Howard D. Aphasia rehabilitation: does generalisation from anomia therapy occur and is it predictable? A case series study. Cortex. 2013 Oct [cited 2020 June 17];49(9):2345-57. doi: 10.1016/j.cortex.2013.01.005. Epub 2013 Feb 4. PMID: 23608067.
28. Ivanova MV, Hallowell B. A tutorial on aphasia test development in any language: Key substantive and psychometric considerations. Aphasiology. 2013 Jan 1 [cited 2024 Feb 1];27(8):891-920. doi: 10.1080/02687038.2013.805728. PMID: 23976813; PMCID: PMC3747007.
29. Hopewell S, Chan AW, Collins GS, Hróbjartsson A, Moher D, Schulz KF, et al. CONSORT 2025 statement: updated guideline for reporting randomised trials. Lancet. 2025 [cited 2024 Feb 1]. doi:10.1016/S0140-6736(25)00672-5.
30. Mumby PJ. Statistical power of non-parametric tests: a quick guide for designing sampling strategies. Mar Pollut Bull. 2002 Jan [cited 2025 June 10];44(1):85-7. doi: 10.1016/s0025-326x(01)00097-2. PMID: 11883688.
31. Lenhard W, Lenhard A. Computation of effect sizes [Internet]. Psychometrica; 2022 [cited 2025 Jun 21]. Available from: https://www.psychometrica.de/effect_size.html. doi:10.13140/RG.2.2.17823.92329
32. Cohen J. Statistical Power Analysis for the Behavioral Science. 2nd ed. New York: Routledge; 1988.
33. Thaut MH, Hoemberg V. Handbook of neurologic music therapy. New York, NY: Oxford University Press; 2014.
34. Liang B, Du Y. The Functional Neuroanatomy of Lexical Tone Perception: An Activation Likelihood Estimation Meta-Analysis. Front Neurosci. 2018 Jul 24 [cited 2024 Feb 1];12:495. doi: 10.3389/fnins.2018.00495. PMID: 30087589; PMCID: PMC6066585.
35. Zhang X, Li J, Du Y. Melodic Intonation Therapy on Non-fluent Aphasia After Stroke: A Systematic Review and Analysis on Clinical Trials. Front Neurosci. 2022 Jan 27 [cited 2024 Feb 1];15:753356. doi: 10.3389/fnins.2021.753356. PMID: 35153655; PMCID: PMC8829877.
36. Ashaie SA, Hurwitz R, Cherney LR. Depression and Subthreshold Depression in Stroke-Related Aphasia. Arch Phys Med Rehabil. 2019 Jul [cited 2024 Feb 1];100(7):1294-1299. doi: 10.1016/j.apmr.2019.01.024. Epub 2019 Mar 2. PMID: 30831094.
37. Mitchell AJ, Sheth B, Gill J, Yadegarfar M, Stubbs B, Yadegarfar M, Meader N. Prevalence and predictors of post-stroke mood disorders: A meta-analysis and meta-regression of depression, anxiety and adjustment disorder. Gen Hosp Psychiatry. 2017 Jul [cited 2024 Feb 1];47:48-60. doi: 10.1016/j.genhosppsych.2017.04.001. Epub 2017 Apr 3. PMID: 28807138.
38. Brady MC, Kelly H, Godwin J, Enderby P, Campbell P. Speech and language therapy for aphasia following stroke. Cochrane Database Syst Rev. 2016 Jun 1 [cited 2020 June 17];2016(6):CD000425. doi: 10.1002/14651858.CD000425.pub4. PMID: 27245310; PMCID: PMC8078645.
39. Shafer JS, Shafer PR, Haley KL. Caregivers navigating rehabilitative care for people with aphasia after stroke: a multi-lens perspective. Int J Lang Commun Disord. 2019 Jul [cited 2020 June 17];54(4):634-644. doi: 10.1111/1460-6984.12467. Epub 2019 Mar 18. PMID: 30884057; PMCID: PMC6609487.
40. Johansson MB, Carlsson M, Sonnander K. Working with families of persons with aphasia: a survey of Swedish speech and language pathologists. Disabil Rehabil. 2011 [cited 2024 Feb 1];33(1):51-62. doi: 10.3109/09638288.2010.486465. Epub 2010 May 10. PMID: 20455706.
41. Hassan FH, Zakaria AS, Ahmad Rusli Y, Haris SM, Mohd Azraai H. Comparisons of Clients' and Caregivers' Satisfaction Across Conventional, Virtual, and Hybrid Speech-Language Therapy Services in Malaysia. Patient Prefer Adherence. 2023 Jul 19 [cited 2024 Feb 1];17:1731-1740. doi: 10.2147/PPA.S407347. PMID: 37492636; PMCID: PMC10363485.
42. Wanicharoen N, Boonrod V, Kalaysak T, Samueanjai S. A systematic review of melodic intonation therapy used by speech therapists on speech recovery for patients with non-fluent aphasia. J Assoc Med Sci. 2024 [cited 2024 Feb 1];57(3):212-20.
43. Haro-Martínez A, Pérez-Araujo CM, Sanchez-Caro JM, Fuentes B, Díez-Tejedor E. Melodic Intonation Therapy for Post-stroke Non-fluent Aphasia: Systematic Review and Meta-Analysis. Front Neurol. 2021 Aug 4 [cited 2024 Feb 1];12:700115. doi: 10.3389/fneur.2021.700115. PMID: 34421802; PMCID: PMC8371046.
44. Graff-Radford J, Jones DT, Strand EA, Rabinstein AA, Duffy JR, Josephs KA. The neuroanatomy of pure apraxia of speech in stroke. Brain Lang. 2014 Feb [cited 2025 June 10];129:43-6. doi: 10.1016/j.bandl.2014.01.004. Epub 2014 Feb 18. PMID: 24556336; PMCID: PMC4004427.
45. Slavin D, Fabus R. A Case Study Using a Multimodal Approach to Melodic Intonation Therapy. Am J Speech Lang Pathol. 2018 Nov 21 [cited 2025 June 10];27(4):1352-1362. doi: 10.1044/2018_AJSLP-17-0030. PMID: 30120439.
46. Robey RR. A meta-analysis of clinical outcomes in the treatment of aphasia. J Speech Lang Hear Res. 1998 Feb [cited 2020 June 17];41(1):172-87. doi: 10.1044/jslhr.4101.172. PMID: 9493743.
47. van der Meulen I, van de Sandt-Koenderman ME, Ribbers GM. Melodic Intonation Therapy: present controversies and future opportunities. Arch Phys Med Rehabil. 2012 Jan [cited 2020 June 17];93(1 Suppl):S46-52. doi: 10.1016/j.apmr.2011.05.029. PMID: 22202191.
48. Saur D, Lange R, Baumgaertner A, Schraknepper V, Willmes K, Rijntjes M, Weiller C. Dynamics of language reorganization after stroke. Brain. 2006 Jun [cited 2024 Feb 1];129(Pt 6):1371-84. doi: 10.1093/brain/awl090. Epub 2006 Apr 25. PMID: 16638796.
49. Popescu T, Stahl B, Wiernik BM, Haiduk F, Zemanek M, Helm H, Matzinger T, Beisteiner R, Fitch WT. Melodic Intonation Therapy for aphasia: A multi-level meta-analysis of randomized controlled trials and individual participant data. Ann N Y Acad Sci. 2022 Oct [cited 2024 Feb 1];1516(1):76-84. doi: 10.1111/nyas.14848. Epub

2022 Aug 2. PMID: 35918503; PMCID: PMC9804200.
50. Schlaug G, Marchina S, Norton A. Evidence for plasticity in white-matter tracts of patients with chronic Broca's aphasia undergoing intense intonation-based speech therapy. Ann N Y Acad Sci. 2009 Jul [cited 2025 June 10];1169:385-94. doi: 10.1111/j.1749-6632.2009.04587.x. PMID: 19673813; PMCID: PMC2777670.
51. Stefaniak JD, Halai AD, Lambon Ralph MA. The neural and neurocomputational bases of recovery from post-stroke aphasia. Nat Rev Neurol. 2020 Jan [cited 2025 June 10];16(1):43-55. doi: 10.1038/s41582-019-0282-1. Epub 2019 Nov 26. PMID: 31772339.
52. Kośla K, Pfajfer L, Bryszewski B, Jaskólski D, Stefańczyk L, Majos A. Functional rearrangement of language areas in patients with tumors of the central nervous system using functional magnetic resonance imaging. Pol J Radiol. 2012 Jul [cited 2025 June 10];77(3):39-45. doi: 10.12659/pjr.883373. PMID: 23049580; PMCID: PMC3447432.
53. Patel R, Connaghan KP, Campellone PJ. The effect of rate reduction on signaling prosodic contrasts in dysarthria. Folia Phoniatr Logop. 2013 [cited 2020 June 17];65(3):109-16. doi: 10.1159/000354422. Epub 2013 Nov 26. PMID: 24296946.
54. Gentilucci M, Dalla Volta R. Spoken language and arm gestures are controlled by the same motor control system. Q J Exp Psychol (Hove). 2008 Jun [cited 2020 June 17];61(6):944-57. doi: 10.1080/17470210701625683. PMID: 18470824.
55. Morrow-Odom KL, Swann AB. Effectiveness of melodic intonation therapy in a case of aphasia following right hemisphere stroke. Aphasiology. 2013 [cited 2020 June 17];27(11):1322-38. doi:10.1080/02687038.2013.817522.
56. Katz RC, Wertz RT. The efficacy of computer-provided reading treatment for chronic aphasic adults. J Speech Lang Hear Res. 1997 Jun [cited 2025 June 10];40(3):493-507. doi: 10.1044/jslhr.4003.493. PMID: 9210109.