# Neural Mechanisms in Music Therapy for Language Disorder Intervention

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**Abstract.** This study investigates how music therapy helps treat language disorders. It examines the neural mechanisms behind this process. Music and language share some neural processing networks. This paper explore these shared pathways and their clinical relevance. This paper also discuss the future potential and challenges of music therapy. This paper reviewed 25 relevant studies from Google Scholar and CNKI published between 2004 and 2025. Keywords included neurolinguistics, music therapy, and language disorders. Results show that music therapy improves language function. This improvement relies on brain regions such as Broca's area and Wernicke's area. These regions are involved in both music and language processing. Techniques such as Melodic Intonation Therapy (MIT) and Rhythmic Auditory Stimulation (RAS) activate shared neural networks. They promote neuroplasticity. Music also triggers semantic processing. This provides neurobiological support for music therapy. Music therapy is a promising and scientifically supported intervention for language rehabilitation. Future studies should develop more culturally adapted and precise treatment plans.

**Keywords:** Music Therapy; language disorders; Melodic Intonation Therapy (MIT); Rhythmic Auditory Stimulation (RAS); neuroplasticity.

## 1. Introduction

Music is a universal language. It crosses cultural and ethnic boundaries. Music has calming effects and is increasingly used as a therapy. The history of music therapy dates back to the late 19th century. At that time, professional music therapists first appeared. By the early 20th century, music therapy was used in hospitals. It served mainly as a complementary treatment for relaxation and rehabilitation. In the mid-20th century, music therapy became a recognized discipline in the United States. World War II accelerated its development. Many countries, especially the U.S., focused on rehabilitating veterans. In 1974, the World Federation of Music Therapy was founded. Since then, the field has grown rapidly. In developed regions such as Europe, the U.S., and Japan, music therapy is now a recognized profession [1].

Language disorders are diagnosed based on specific criteria. These include significantly reduced language ability compared to peers, problems in social communication, and ruling out other conditions like hearing loss or intellectual disability [2, 3]. Language disorders greatly affect social functioning and quality of life. Traditional therapies only partially address these issues. Many language difficulties remain. Non-drug treatments like music therapy show great promise. They complement conventional medicine [4]. Martina de Witte and colleagues have discovered that music therapy, particularly receptive techniques or the integration of receptive and active approaches, provides effective, adaptable, and scalable interventions for alleviating anxiety symptoms. It offers psychological advantages that enhance patients' autonomy and quality of life. However, its influence on physiological outcomes and long-term effects still needs further research. [5]. Several methods—such as Ulwila [6], MIT, and RAS—are now used in clinics. Studies show that music therapy improves attention, emotion, cognition, behavior, communication, and sensory regulation in people with language disorders. This paper explores how music therapy helps treat language disorders. It analyzes the neural mechanisms involved. It also identifies which brain regions and networks play a role. Finally, it discusses the future applications of music therapy.

## 2. Literature Review

This paper searched Google Scholar and CNKI for studies from 2004 to 2025. This paper found 23 relevant papers. Keywords included: neurolinguistics, music therapy, language disorders, and music-language relationship. This paper focused on the following questions: How effective is music therapy for language disorders? What neural mechanisms are involved? Do music and language use the same brain networks? What challenges does music therapy face?

Standard treatments often fail to address complex neurocognitive deficits. Long-term rehab for neurological disorders is also costly. Therefore, new strategies are needed [7]. Music therapy is now mainly used as a add-on to clinical care [8]. Music rhythm training as an additional, potentially effective therapeutic tool to enhance speech/language processing in these disorders [9]. Musical experience improves general sound perception. It also helps with language-specific processing, such as tone recognition [10]. This supports the use of music therapy for language disorders.

### 2.1. Neural Connections Between Music and Language

#### 2.1.1 Shared brain networks and regions

Neuroimaging and electrophysiological data show that music affects limbic and parahippocampal structures. These are key regions for emotion processing. Music perception also triggers brain activity related to action and language. Huang's team found that music therapy helped adults better track Chinese tone pitches. This suggests that music therapy affects basic perceptual mechanisms in language [12]. It not case reduces perceptual challenges—it also supports language development. Evidence shows that music therapy improves many aspects of language. These include phonetic tracking, phonological awareness, and reading comprehension [13].

Music and language are processed in similar ways. Both start with acoustic feature extraction. Both use hierarchical processing. Lower-level processing shows more similarity than higher-level processing [14]. Brain regions such as the superior temporal gyrus, middle temporal gyrus, insula, and inferior temporal gyrus are involved in both music interval analysis and semantic processing [15]. Melody processing activates Broca's area and Wernicke's area. These are important for language and syntax. This suggests that music and language share syntactic processing mechanisms.

#### 2.1.2 Semantic processing and electrophysiological evidence

The N400 is an event-related potential (ERP). It appears between 300–500 ms after a stimulus. It reflects semantic or conceptual processing. The N400 amplitude shows how much cognitive effort is needed for semantic integration. This component is also used to study musical meaning [16]. In Koelsch's experiments, music caused an N400 effect similar to that in language. This effect came from the bilateral middle temporal gyri. This means that music can activate semantic concepts. It also supports the use of music therapy for language disorders [17].

### 2.2. Main Music Therapy Interventions

#### 2.2.1 Melodic Intonation Therapy (MIT)

MIT is a treatment for aphasia. It is especially helpful for patients with damage to Broca's area. It uses melodic patterns that match speech prosody to restore speaking ability [18].

According to the research of F Impellizzeri etc., the MIT training led to substantial improvements across all neuropsychological assessments. Notable increases were observed in spontaneous speech, verbal comprehension, word repetition, and naming. The overall AQ improved, indicating a shift from severe to moderate aphasia [19]. According to Bankoski, E.'s research, MIT works best with early intervention for subacute patients, using unison production and personalized tasks to maintain engagement [20]. Also, in research conducted by Marchina, S., Norton, A., & Schlaug, G, the imaging data of the experimental results proved that intensive treatment of MIT improved speech output and fluency, accompanied by fMRI changes in aright-hemisphere network, with changes in the right posterior IFG correlating with fluency gains [21].

#### 2.2.2 Rhythmic Auditory Stimulation (RAS)

RAS uses rhythm (like music or beats) to stimulate the motor cortex. It improves motor skills. MIT and RAS activate alternative neural pathways and promote neuroplasticity, enhancing emotional regulation, cognition, language expression, and motor function in stroke patients. According to Gonzalez-Hoelling, S. etc., the best available evidence suggests that functional ambulation ability of chronic stroke patients improves after an intervention with music or rhythmic auditory stimulation and that the gains are greater than with no treatment or conventional therapy [22]. Also, research has shown that in addition to improvement in gait and motor function, RAS can influence attentional processes, memory, language and speech production, and semantics [23].

### 2.3. Challenges and Future Directions

#### 2.3.1 Limitations and Translation Issues

Current research has limitations. For example, most neuroimaging results come from lab settings. Also, many studies do not clearly describe the music genres used. Different genres (e.g., stimulating vs. calming music) have different effects. They affect physiological measures, neural arousal, and emotions in distinct ways. Also, the assessment tool chosen may not sensitive enough to capture subtle changes in the participants' social skills [24].

#### 2.3.2 Cross-Language Differences: Chinese Tones

Treatment methods should adapt to different languages. Chinese is a tonal language, so aphasia treatment methods here ought to differ from those applied in Western languages. Currently, prevalent Speech-Language Therapy (SLT) techniques in China encompass Schuell's Stimulation Approach, Melodic Intonation Therapy, and Constraint-Induced Aphasia Therapy. Yet, their insufficient spread is impeded by gaps in healthcare infrastructure and a lack of trained specialists, especially in rural regions. However, existing research has predominantly focused on Indo-European languages, with limited evidence from paratactic languages such as Mandarin Chinese [25]. Although MIT principles offer a promising foundation, the tonal variations and complexities in languages such as Mandarin, Thai, or Vietnamese require nuanced adaptations. Further research could focus on refining MIT techniques to address the distinct tonal challenges that learners encounter in various tonal languages. Future studies should consider the features of Chinese tones, how MIT can be adapted for Chinese patients can be explored.

## 3. Conclusions

This review supports the application of music therapy for language disorders. Music therapy effectively improves language disorders. It works through shared brain regions including Broca’s area, Wernicke’s area, superior temporal gyrus, middle temporal gyrus, and insula. Methods like MIT and RAS activate these shared networks. Music activates semantic concepts. Neurophysiological markers like the N400 provide evidence for its use. Music therapy is a neuroscience-based intervention with broad applications in rehab, which should be adapted to different languages and cultures. At present, SLT techniques such as Schuell's stimulation are the main therapies in China. Due to differences in medical foundations and a lack of professional personnel, these methods haven’t been utilized to provide good services to relevant patients, more localized and personalized treatments should be developed in the future.

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