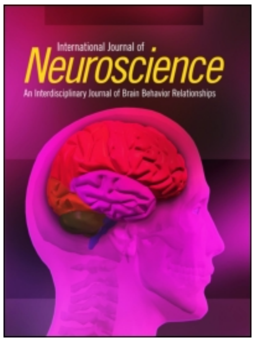


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# The role of music therapy in rehabilitation: improving aphasia and beyond

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**Abstract**

Music is part of the human nature, and it is also philogenically relevant **to** language evolution. Language and music are bound together in the enhancement of important social functions, such as communication, cooperation and social cohesion. In the last few years, there has been growing evidence that music and music therapy may improve communication skills (but not only) in different neurological disorders. One of the plausible reasons concerning the rational use of sound and music in neurorehabilitation is the possibility to stimulate brain areas involved in emotional processing and motor control, such as the fronto-parietal network.

In this narrative review, we are going to describe the role of music therapy in improving aphasia and other neurological disorders, underlying the reasons why this tool could be effective in rehabilitative settings, especially in individuals affected by stroke.

**Keywords:** music therapy; aphasia; rehabilitation.

Introduction

Aphasia is an impairment of language, affecting the production or comprehension of speech and the ability to read or write, **and leading to different grades of disability**. This can be either very mild or so severe that communication with the patient results almost impossible. Although aphasia may affect a single aspect of language (such as the ability to retrieve the names of objects, arrange words to make sentences, or read), multiple aspects of communication are more commonly impaired at the same time, and just a few channels remain accessible for a limited exchange of information.

Aphasia is often due to brain injuries such as stroke, head trauma, brain tumors or infections. Any brain lesion involving the encephalic regions responsible for speech elaboration and production (i.e. Wernicke and Broca areas) can cause aphasia. In recent years, stroke has become one of the leading causes of adult disability worldwide, with an estimated prevalence of 33 million stroke survivors [1]. Several post-stroke individuals may suffer from co-morbid motor speech problems, such as speech apraxia and dysarthria [2], beyond the deficit of several areas of communication, such as speaking, understanding spoken words, reading and writing. **In particular, apraxia of speech is an acquired oral motor speech disorder affecting an individual's ability to translate conscious speech plans into motor plans, which results in limited and difficult speech ability. Apraxia of speech and Broca's aphasia are commonly mistaken as the same disorder mainly because they often occur together in patients. Although both disorders present with symptoms such as a difficulty producing sounds due to damage in the language parts of the brain, they are not the same. The main difference between these disorders lies in the ability to comprehend spoken language; patients with apraxia are able to comprehend speech, while patients with aphasia are not always fully able to do it [2].**

The reduced mortality following acute stroke has made **it** possible to improve the clinical conditions of a growing number of patients, paving the way to new perspectives in patients' rehabilitation.

Appropriate management and rehabilitation of language impairments is of major importance in post-stroke patients. Nonetheless, a recent Cochrane review has pointed out **that music interventions may be beneficial for communication outcomes in people with aphasia following stroke, although it is unclear which types of therapy are efficacious** [3]. High intensitiy specific- and deficit-oriented therapy may only result in a moderate treatment effect size, since this kind of training focuses exclusively on the "affected area" [4]. Furthermore, whether or not speech rehabilitation should be continued also in the long term after the acute event needs to be further investigated.

High costs and limited availability of speech therapists are two major issues of post-stroke aphasia rehabilitation, so new low-cost and easily accessible approaches are required to enhance living with chronic stroke [5,6].

In the last few years there is growing evidence that music and music therapy (MT) may improve communication skills in different neurological disorders [7,8,9]. Indeed, it is possible to affirm that post-stroke aphasic patients can often sing despite the inability to speak, considering the following perspectives: i) singing is innate to all humans; ii) singing and speaking brain networks partially overlap; iii) singing involves greater neural circuitry [10,11], which may be preserved following a stroke. These findings have led to the development of Melodic Intonation Therapy (MIT), the first formalized music-based rehabilitation treatment for aphasia [12]. MIT uses musical components to facilitate verbal expression and ameliorate propositional language, which needs the association of phonological, morphological, and grammatical rules with lexicon [12,13].

One of the plausible reasons concerning the rational use of sound and music in neurorehabilitation **(with regard to communication disorders, including expressive aphasia and apraxia of speech)** is the possibility to stimulate brain areas involved in emotional processing and motor control. It has been reported that the effect of music on the frontal areas of the brain may constitute one of the cornerstones of its use in neurological rehabilitation both in musicians and in patients without musical skills [14,15].

In this narrative review, we are going to describe the role of music therapy in improving aphasia, underlying the reasons why this tool is effective, as well as when and how it can be used in a rehabilitative setting, especially in individuals affected by stroke.

Literature dealing with music therapy  and neurological disorders has been reviewed to highlight the most important works on the topic. To this end, previous reviews, randomized controlled trials and observational studies, involving exclusively or primarily studies with music therapy have been evaluated. PubMed and the Cochrane Library literature searches have been carried out using such terms as music therapy, music, melodic intonation therapy, **Choral Singing Therapy** combined with each of the following terms: fMRI, aphasia, stroke, disorders of consciousness and rehabilitation, for significant articles published between 1990 and 2016. The emerging methods showing a potential benefit in treating language and speech disorders in neurological diseases have been described.

Brain structures and music

Neural events underlying music perception take place across the cochlea, the brainstem, diencephalic and telencephalic structures **[20-21].** What is commonly defined as music and all the other sounds from which it is distinguished are mainly processed by sharing the same neural substrates **[22].** In addition, music-related activities, such as singing, might recruit areas, which partially overlap with those involved in speech production (see below). However, **growing evidence underlines** a functional segregation in music processing. Indeed, acute injury of the brain may selectively affect music perception saving the language or, on the contrary, may preserve music perception destroying the language, showing that the two functions are located in different areas **[15].**

During the last decade, there has been a growing interest in understanding the mechanisms underlying music production and listening, and how music processing may be useful for patients' rehabilitation [14]. Furthermore, anatomical differences in specific brain areas between musicians and non-musicians have been investigated in recent years. Altenmüller et al. [15] found that playing music might promote the synaptic plasticity in the motor system, even in those patients who did not have musical abilities. The development of music skills might strengthen the connections between motor areas and acoustic areas thus leading to cognitive enhancements as well [16].

Finally, it has been **outlined** how music could represent a powerful multimodal stimulus that drives visual, auditive and motor information in order to facilitate the connections between several neural networks, with a potential rehabilitative value [17].

The idea that music functions are localized mainly in the right cerebral hemisphere emerged in the sixties from studies conducted on both normal and pathological subjects. Normal individuals can be studied by means of the dichotic listening technique (i.e. two acoustic inputs, which are different but of equal entity, are simultaneously given to a subject to investigate the selective attention within the auditory system). **In the work by Kimura, subjects were given two auditory tests: one consisting of spoken digits presented dichotically while the other of melodies presented dichotically; on the Digits test, the score for the right ear was higher than for the left, whereas on the Melodies test the score for the left ear was higher than for the right.** The author concluded that listeners were able to better recognize common songs (selected from classic instrumental repertoire, of commercial recordings) within the right cerebral hemisphere.

In the same period, it has been shown that a partial ablation of the right temporal lobe decreased the patient's response to detection of pseudo-music sequences more than it was expected in case of left hemisphere's lesions [19].

Music processing in the brain is based on pitch (melodic) and time relations. **Results emanetig from both lesion studies and neuroimaging techniques support the idea that the different musical elements are processed by different brain areas;** for a more exhaustive review we recommend the reader to read Peretz et al. 2005 [20] Evidence for functional lateralization come from studies focusing on brain lesions or non-invasive techniques such us EEG, MEG [21]. Pitch relations are computed in the right temporal neocortex, in the antero-lateral part of **the** Heschl gyrus and in the secondary auditory cortex region. The two main kinds of time relations, grouping and regularity are likely to be computed in the right and left hemisphere, respectively **[10].** In addition, neuroimaging studies have shown that both cerebellum and basal ganglia contribute to motor and perceptual timing [22]. Medial and lateral cerebellum areas are likely to be involved in different timing features, since lesions involving lateral cerebellar regions lead to perceptual time impairments, while lesions to medial cerebellum alter the timing variability associated with the motor response [23,22].

A plausible explanation to the mechanisms underlying motor timing in the cerebellar cortex has been recently proposed, suggesting that learning is known to depend on the cerebellar cortex where Purkinje cells respond with adaptively timed pauses in their spontaneous firing [24].

Many fMRI studies pointed out the contribution of basal ganglia both in motor and perceptual timing [25,26] thus suggesting a possible interplay between cerebellum and basal ganglia in timing control [27,28]. Although melody and rhythm play a key role in music processing, the most important features of music experience (which makes it essential in everyday life) are the emotions triggered by music. Several fMRI and PET studies have tried to identify the neural substrates underlying complex emotions elicited by music [29-32].

In particular, it has been demonstrated that pleasurable music evoking joy and happiness activate the ventral striatum, thus suggesting a dopamine-based substrate. Several authors showed that the areas commonly activated during happiness are the orbito-frontal cortex, the anterior insula and the somatosensory areas [33], whilst unpleasant emotional states such as fear, anxiety, tension, which are triggered by sad music, have been reported to activate the hippocampus and amygdala [34,35].

These studies employed a dichotomous design, classifying only pleasant/unpleasant emotions thus restricting the actual range of complex emotions triggered by music. However, a new statistical-based model designed 9 emotion**al** factors to describe the subjects' emotional reaction [36] i) joy; ii) sadness; iii) tension; iv) wonder; v) peacefullness; vi) power; vii) tenderness; viii) nostalgia. Recent fMRI parametric studies based on the intensity of emotions felt by the subject, studied the overlap between complex and basic emotions induced by music [29]. This model has been further updated grouping the 9 emotion**al** factors into three classess: Vitality, Unease, and Sublimity, which partially overlap the dimentions of arousal and valence. Notably, sublimity has to be conceived as the sense of beauty and perfection given by every form of art **[32-35]**.

A positive valence was related to an increased activity in ventral striatum, caudate, visual and auditory areas, posterior and anterior cingulum, whereas negative valence was related to an increased activity of the orbitofrontal cortex and right insula, as reported in previous works **[34].** Low arousal states, like nostalgia and tenderness, increased the activities in the hippocampus, ventromedial preforntal cortex and parahippocampal gyrus, which are thought to associate autobiographical memory to music **[32-34].** Motor structures such as caudate nucleus and cerebellum showed different patterns of activation when elicited by power and wonder feelings **[36].** Negative emotions and sadness were associated to an increased activity in the subgenul anterior cingulate cortex, whilst fearful music was accounted to increase activity in the amygdala [37].

In order to fully appreciate the richness and multidimensionality of emotion reactions to music, a deeper knowledge on the complex pathways underlyning music perception and processing is needed. Many researches have pointed out that sound and music are capable of activating the fronto-temporo-parietal regions, particularly those neural networks belonging to the mirror neurons system that strengthens the correlation between visual/auditive perception and the motor component of the action and allows empathy with other people [38, 39]. Growing evidence **shows** the important role of mirror neurons (a class of neurons activated when an individual performs an action and when the individual observes the same action performed by another person) in the listening and production of music [40,41]. It has been hypothesized that music and language processing share some neural substrates including mirror neurons. In an fMRI study, Lahav et al. [42] recorded brain activity in subjects listening to a newly acquired piece of music. Although the subjects listened to the music without performing any movement, activation was found bilaterally in the frontoparietal motor-related network, including Broca's area, the premotor region, the intraparietal sulcus, and the inferior parietal region. Hence, the hypothesis of a possible overlap between neural circuits and action observations, potentially constituting the human audiovisual mirror neuron system. However, further investigations should be fostered in order to provide strong evidence supporting such promising hypothesis.

Notably, different studies performed in healthy individuals demonstrated that the dominant hemisphere for musicians was the left one, while for non-musicians the right one. These findings supported the hypothesis that musical skills may play a role **in** brain re-organization [43].

The neural correlation of musical skills may also be deduced by studies in patients with neuropsychiatric conditions. People affected by autism with intellective deficits are often defined by the unflattering term of "idiots savants" (i.e. "idiots wise"), or "musicians-wise", since a relatively high percentage of them presents musical skills. Thus, **it is possible that such disease does not affect the brain areas involved in music perception and production.**

The use of music therapy in neurological diseases

A complete definition of MT can be found in the "Manual of Music therapy" by Rolando Benezon [44], who considers both the scientific and therapeutic aspects of this therapy. From a scientific point of view, MT is considered as "a discipline dealing with the study and research of the complex sound-human being (musical sound is not) with the objective of search for elements of diagnosis and therapeutic methods".

From a therapeutic point of view, music therapy is instead a "paramedical discipline that uses sound, music and movement to cause retrogressive effects and open channels of communication, with the objective of activating a process of socialization and social inclusion".

Music is an excellent "medicine" for different neurological disorders, including Parkinson Disease. Singing a song with certain rhythmic features, be it even only mental, helps patients to walk better and to improve some of the typical problems of the disease **[45].** Indeed, the use of particular songs could be assumed as a step metronome in these patients, leading to gait improvement [45], maybe via the rhythm action on the basal ganglia. This represents the first scientific proof of an empirical method, which has long been used by Japanese therapists to improve walking in parkinsonian patients [45].

Music therapy is often used in the diagnosis and treatment of patients with disorders of consciousness (DOC). An fMRI study revealed the activation of amygdala in a long-term comatose patient when exposed to a familiar speech or sounds, leading to suppose the presence of potential cognitive and emotional processes also in these fragile individuals [46]. Since several DOC patients showed awareness only in the auditory modality [47], MT could be used as a mean to assess a patient's recovery of various functions by using different parameters such as volume, pitch, melodic contour, rhythm and articulation. The need to refine behavioural responses in order to register small behavioural changes to music has led to the development of the MT assessment tool for low awareness states (MATLAS) [47] and, recently, the MT assessment tool for awareness in disorders of consciousness (MATADOC) [48,49]. Hence, MT is a means to communicate with these patients in order to better understand the awareness state of unresponsive wakefulness syndrome (UWS) and minimal conscious state (MCS) patients. A PET study on four UWS patients has recently assessed the pattern alteration in the brain of people who underwent music therapy [50], demonstrating an increasing tracer uptake in frontal lobes, hippocampus and cerebellum. This represents a further step towards the understanding of music effects on UWS, which however still needs to be clarified [51]. Furthermore, it has also been demonstrated that their favourite music has a beneficial effect on the cognitive abilities of MCS patients, suggesting that cerebral plasticity may be enhanced in emotional autobiographical contexts [52].

Rauscher et al. [53] demonstrated that listening to Mozart K.448 enhances spatial reasoning and memory in rats, the so-called "Mozart Effect", thus paving the way for the study of music's effect on humans. A recent work [54] investigated the effects of Mozart K448 on both rats and humans' behaviour, by using a comparison with the retrograde version of the same piece (as a contrast test for Mozart music). The authors suggested that the nature of Mozart effect is the Mozart rhythm, and indicated that different music may have quite different opposite effects. The Mozart effect could be explained through the activation of a sensory motor circuit mediated by mirror neurons, which could be considered the anatomical substrate conveying auditory stimuli to the motor cortex. Notably, several studies have demonstrated a beneficial effect of Mozart music on epilepsy [55, 56, 57]. In particular, more than 50% of children with refractory epilepsy treated with MT (listening to K448) showed a decrease in seizure frequency by 50%-98% and two had even a 100% remission (seizures free) [57]. Music is known as an agent that increases dopamine levels, and this could somehow explain the beneficial effects of music on epilepsy.

Music therapy for Stroke treatment: an overview

Stroke is one of the most common causes of motor and cognitive disability worldwide. One of the main consequences of stroke is a mild to severe impairment of language, i.e. aphasia. Along with difficulties in word retrieval, which affects the ability of arranging sentences, aphasic patients often suffer from the consequent lack of communication with a compromised social integration. Post-stroke depression (PSD) is often mentioned in studies involving stroke patients. Thus, PSD evaluation is highly recommended to healthcare-providers, given that PSD is experienced by 14-46% of stroke survivors. [58]. Despite motor and cognitive manifestations remain the main targets for therapy, low mood and social isolation make neurorehabilitation even more difficult.

The beneficial effects of active singing on stroke patients' quality of life are known, taking into account that the improvement of their conditions in a wide range of psychosocial measures, such as mood, anxiety and motivation. The choir singing benefits were formally reported for the first time in 2012, when 20 stroke survivors were engaged in choral singing to improve both classical aphasia impairments and post stroke mood disorders [59]. Choral singing therapy (CST) is a feasible treatment protocol aimed at improving patients' quality of life through a community approach to singing fully supported by therapists [60]. Suggestive findings are also reported by Fogg-Rogers et al. in a recent study including both stroke and

Parkinson disease patients involved in CST; the authors have shown positive impact on mood, motivation, self-confidence and socialization. [60]. Choir members initially sang mainly familiar songs which were adapted in order to increase repetition and avoid confusion, then they where encouraged to tap the rhythm while singing [60], thus enhancing cortical activity in sensorimotor and premotor areas [61]. It is likely that the rhythm plays a key role in CST efficacy, allowing subjects affected by severe aphasia to reach a near-fluent language during choral singing, in line with other approaches. [62,63,64].

Focus on post-stroke aphasia

Although the neural mechanisms underlying post-stroke aphasia recovery continue to remain unclear, some hypothesis have been proposed: i) in small left-hemisphere lesions, the left-hemispheric perilesional cortex may be recruited to compensate for the ischemic area; ii) in large left-hemispheric lesions, homologous speech-motor and language regions may be recruited in the right hemisphere; however, this process is thought to be less efficient than the former [65, 66, 67]. The hypothesis according to which the rehabilitation of patients could be improved by making them sing is supported by several evidences [59].

Singing is considered to have a positive effect on patients suffering from post-stroke aphasia, facilitating speech at the motor [68], motivational, and word retrieval levels [69,70].

The most common varieties of aphasia are the fluent and non-fluent forms; the former is characterized by the inability to understand the meaning of written and spoken words, resulting in a severe impairment in reading and writing [71]. In non-fluent aphasia, instead, patients are able to read and understand speech relatively well, although writing, vocabulary access and formation of sound may be limited. Indeed, severe decrease of speech output, agrammatism, and apraxia of speech represent main features of this form of aphasia, playing a major role as clinical markers to differentiate non-fluent aphasia from other forms of aphasia [71,72]. On the other hand, patients with global aphasia are neither able to understand spoken language nor able to read, write, repeat words or name objects [71].

Although several cognitive, psycholinguistic and psychosocial procedures have been used for the rehabilitation of post-stroke aphasia patients, efficacy may vary among subjects due to the different intensity of treatment and the lack of rehabilitative approaches adequate to individual patient's needs [73].

Taking into account that **some** patients with aphasia can produce articulated words while singing, but not during speech [74], melody-, rhythm- and singing-based treatments have shown to be promising tools in treating language and speech disorders in aphasia [75-78]. Although the most common therapeutic protocol is MIT, during the last decades other different therapeutic trainings, including MMTI (Modified Melodic Intonation therapy), SIPARI (Singing, Intonation, Prosody, breathing, Rhythm) and SMTA (Speech-Music therapy for aphasia), have been designed [79]. MIT is the most widely used approach for post-stroke aphasia patients**;** however, it is not to be considered strictly as MT, since more recent techniques such as SMTA take advantage of more musical elements (dynamics, tempo and metre) [79]. Indeed, SMTA combines MIT and speech language therapy in one session and articulates rehabilitation of speech at three levels: sound, word and sentence level. SMTA employs new melodies sung by the patients together with the speech therapist, in order to avoid word retrieval and to promote a new experienced-based approach [80]. Studies conducted on patients who suffered from Broca and global aphasia treated with SIPARI method highlighted the contribution of a music-based training in improving expressive speech elements such us spontaneous speech, repetition, naming. SIPARI® method, consisting of selected exercises involving each point of the acronym, is likely to improve comprehension, which is related to auditory processing involved in repetition [77].

Raglio et al. [76] demonstrated that speech language therapy in post-stroke aphasia led to better results when coupled with MT, as revealed by increased scores of spontaneous speech. In addition, 50% of the patients who underwent the combined MT-speech language therapy showed an improvement in the vitality score; on the other hand, this improvement was present in none of the patients treated with speech-language therapy alone, thus supporting the major role of MT in the rehabilitation of post-stroke aphasia patients.



Music therapy in rehabilitation: focus on the melodic intonation therapy

Currently, musicotherapic practices are very different from one another and are object of intense research activities especially in the clinical environment.

First, while structuring rehabilitation training, a therapist should take into account how far the musical experience could subjectively influence patients, because some may not have benefits from MT. In a person particularly receptive to music, a sort of "identification" with the music may be observed, and the subject may experience feelings, emotions and sensations; if listening to music is instead lived with a defensive stance, the effects on the emotional side could be tiny, thus being MT ineffective [81].

MIT is the most well known singing-based therapy, introduced for English speakers in 1974 by Sparks [12]. The birth of this new type of therapy was surely based on the observation that certain aphasic patients could still recite a prayer and singing old songs, taking also into consideration that part of them were capable of outputting more easily a word if this was included in popular songs [82].

The main features of the method are represented by the intonation of common phrases at a slow pace with left hand-tapping at each syllable, following a hierarchy of steps that eventually moves from singing to speech [82,83]. Several therapeutic approaches further implement the intoned- speech that remains the main facilitation technique used in MIT. The method has to be conceived as a treatment program, so the whole facilitation techniques and their efficacy in rehabilitation must be considered. Nonetheless, various facilitation techniques combined with the original MIT in clinical practice make it hard to clearly define such rehabilitation method. Although intoned-speech is such a constant in MIT, it could be used in different treatment strategies as well [64].

Indeed, vocal intonation is proposed along with other MT practices in a protocol providing working guidelines for non-fluent aphasia treatments different from MIT. In this study, intoned speech aims to help patients to convey different meanings in speech improving melodic components of prosody [64]. MIT success has spread throughout the world, so that it has been widely modified by clinicians and researchers. An exhaustive review on deviations from the original MIT has been recently proposed [78] together with several works concerning MIT modification [84, 85, 86]. MIT is primarily directed to the language, but many therapists have had considerable success by adapting it to improve the articulation of speech and to reduce the frequency of phonemic mistakes made by their patients.

Thus, speech-language pathologists use MIT as a treatment program for the rehabilitation of patients with speech production disorders, including apraxia of speech and dysarthria. This technique was initially based on the hypothesis that the regions of the right cerebral hemisphere involved in music processing had language capabilities, and that they could potentially allow for a compensation of those damaged left hemisphere regions responsible for language. The contemporary introduction of left hand-tapping was thought to stimulate language-capable areas in the right hemisphere [78].

MIT has particularly developed to facilitate the recovery of abilities in severely aphasic adults and to encode the thoughts in significant units of verbal communication. The goal is to recover the formulation of the propositional language rather than to potentiate spoken production. To this end, it has been demonstrated that chronic patients, whose damage involved all the features of language, responded better to this form of therapy than to other therapeutic approaches [87]. However, whether MIT needs to be included in the MT field is still a matter of debate, given that data concerning its efficacy are controversial. Several studies lack especially in design and methodology: summary statistics are often absent because they deal with small samples (single cases and case series studies); information about education, cognitive functions, dominance is not reported in at least half of the studies examined in systematic reviews [88].

A randomized controlled trial involving patients suffering from severe non-fluent aphasia evaluated the effects of MIT during the sub-acute phase, showing greater beneficial effects on language in the MIT-treated groups in nearly all the outcome measures. [88].

More recently, a pilot randomized controlled trial has been conducted also on patients suffering from chronic aphasia, suggesting that the effect of MIT is more restricted in chronic than in earlier stages of stroke. Nonetheless, short-term MIT-related language improvements were found to ameliorate chronic aphasia patients' quality of life. [89-90].

Thus, the highly biased evidences of positive effects together with doubts concerning neural mechanisms underlying MIT raise questions about the effectiveness of this method. However, the ongoing debate could be addressed to MIT deviations, since they probably involve different neural substrates.

Four hypotheses have been suggested to explain the mechanism underlying MIT: i) neural plasticity and re-organization of language related areas; ii) mirror neurons system; iii) the partial overlap between singing and speech pathways; iv) motivation and mood [91]. According to Merrett et al. such hypotheses have to be conceived as non-exclusive, since each one could account for the different ways by which MIT improve language [90].

## Conclusive Remarks

Music is part of the human nature, being philogenically relevant for language evolution too. Language and music are bound together in the enhancement of important social functions such as communication, cooperation and social cohesion. We can assume music as a fundamental means to integrate individuals into a social context, since a patient has to be considered not only for the aphasic deficit and for his language recovery, but as a person with his own psychosocial context.

In this narrative review, we have reported a group of studies highlighting the beneficial role of music in neurological disorders, since MT may elicit both cognitive and emotional processes, potentially leading to a better quality of life.

From an anatomical point of view both the act of listening and playing music are very demanding tasks involving a great variety of brain structures and areas. Neural networks, located within or in proximity of the upper temporal convolution, play a major role in the perception and programming of the music.

Furthermore, as music experiences are included among natural means of rewards, it is necessary to adopt music therapy in aphasic patients not only for language recovery, but also to improve low mood, which is often a consequence of the frustration of the patient being aware of his condition.

Finally, music therapy has demonstrated to be an important tool to communicate with and to assess the responsivity of DOC patients, but also to evoke their emotional responses in order to enhance consciousness recovery. Although literature still lacks of a comprehensive view on how music therapy could be conveniently used in DOC, this research field is currently developing.

In conclusion, we are only at the initial steps of a clear comprehension of the full potentialities that music therapy may have in neuro-rehabilitation and therefore, further studies should be fostered to better clarify the role of this promising tool in the recovery of neurological patients, with regard to those affected by post-stroke aphasia.



**Disclosure of interest.**

*The authors report no conflicts of interest*

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