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Music therapy in stroke rehabilitation

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Abstract

Music therapy is currently used in the rehabilitation of many diseases. It is worth mentioning the possibility of using it in the rehabilitation of stroke-related. Music is a multimodal stimulus that activates many brain structures related to sensory processing, attention, and memory, and can stimulate complex cognition and multisensory integration. Stroke represents one of the most costly and long-term disabling conditions in adulthood worldwide and there is a need to determine the effectiveness of rehabilitation programs. The brain has a large capacity for automatic simultaneous processing and integration of sensory information. Musical training has extensive effects on the brain. One aspect that may be relevant for stroke rehabilitation is that musicians have enhanced subcortical auditory and audiovisual processing of speech and music. Listening to pleasant music activates an interconnected network of subcortical and cortical brain regions. Previous studies have shown rapid functional improvements associated with plastic brain changes due to musical performance, which involved the auditory and integrative a Music Supported Therapy and Melodic Intonation Therapy were proposed to induce plastic changes in the brain in terms of functional connectivity and neural reorganization in the sensorimotor cortex uditory-sensorimotor cortices instead of restricted motor cortical areas.

Key words

music therapy, stroke, rehabilitation

INTRODUCTION

Music goes back a very long way in human experience. Music therapy is now used in many disparate areas—from coronary care units to rehabilitation after a stroke [1]. Music is a multimodal stimulus that activates many brain structures related to sensory processing, attention, and memory, and can stimulate complex cognition and multisensory integration [2, 3, 4, 5]. The brain has a large capacity for automatic simultaneous processing and integration of sensory information. Currently used multisensory stimulation methods in stroke rehabilitation include motor imagery, action observation, training with a mirror or in a virtual environment, and various kinds of music therapy. Non-invasive brain stimulation has showed promising preliminary results in aphasia and neglect. The advance in brain network science and neuroimaging enabling longitudinal studies of structural and functional networks are likely to have an important impact on patient selection for specific interventions in future stroke rehabilitation [5]. Stroke represents one of the most costly and long-term disabling conditions in adulthood worldwide and there is a need to determine the effectiveness of rehabilitation programs in the late phase after stroke for which currently only limited scientific support exists. The general belief has been that treatment of individuals in the late phase of stroke is of no benefit. Today, the concept of brain plasticity gives hope for improvements in rehabilitation that go beyond spontaneous recovery of function [6, 7]. The rehabilitation process should encompass all dimensions of a stroke survivor's life, and rehabilitation programs that address both the social and physical needs of the patients, preferably individually tailored, are therefore highly desirable [7].

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Music therapy in stroke. Daily listening to self-selected music may improve verbal memory and attention after stroke [5, 8]. Musical training has extensive effects on the brain. One aspect that may be relevant for stroke rehabilitation is that musicians have enhanced subcortical auditory and audiovisual processing of speech and music [5, 9, 10]. Musical experience shapes brainstem encoding of linguistic pitch patterns [5, 11], and musical training results in enhanced ability to hear speech in background noise [5, 12, 13, 14].

Auditory attention is important for the development and maintenance of language-related skills, and musical training may aid in the prevention, habilitation, and remediation of individuals with a wide range of attention-based language, listening, and learning impairments [5, 14].

Many studies in humans have demonstrated functional reorganization associated with learning new motor skills [15, 16, 21]. This suggests that the motor cortex might have the potential for functional changes and that training new motor skills might be a responsive therapeutic strategy after brain injury. During the last decade, researchers have paid special attention to the neurophysiological bases of musical processing, especially with respect to the long-lasting effects of fine motor learning [17, 18, 21], auditory motor coupling[19, 21] and the implication of emotion and reward brain networks in these processes [20, 21]. Previous studies have shown rapid functional improvements associated with plastic brain changes due to musical performance, which involved the auditory and integrative auditory-sensorimotor cortices instead of restricted motor cortical areas [2, 21].

Recent animal studies and functional neuroimaging studies in humans have shed some light on the neural mechanisms that mediate these effects. Listening to pleasant music activates an interconnected network of subcortical and cortical brain regions, which includes the ventral striatum, nucleus accumbens (NAc), amygdala, insula, hippocampus, hypothalamus, ventral tegmental area (VTA), anterior cingulate, orbitofrontal cortex and ventral medial prefrontal cortex [8, 22, 23, 24, 25]. VTA produces dopamine and has direct projections to the locus ceruleus (LC), amygdala, hippocampus, anterior cingulate and prefrontal cortex [8, 26]. The VTA-NAc responses are suggested to be related to suppression of aversive stimuli and pain [8, 24] which would account for the effect of music on coping with stress, whereas LC and hypothalamus mediate arousal. Together, this dopaminergic mesocorticolimbic system is crucial for mediating arousal, emotion, reward, motivation, memory, attention and executive functioning [8, 26].

In animals, music listening leads to increased dopamine synthesis in the brain [8, 27, 28]. Increased dopamine directly enhances alertness, speed of information processing, attention, and memory in healthy humans [8, 29].

Music therapy is the clinical and evidence-based use of music interventions to accomplish individualized goals within a therapeutic relationship by professionals who have completed an approved music therapy program [7, 30]. The new approach to clinical practice and research, known as Neurologic Music Therapy (NMT) [7, 31, 32] is based on a neuroscience model of music perception and production, and the influence of music on functional changes in the brain and behaviour functions [7, 33]. Using standardized treatment protocols, NMT is a therapeutic application of music to cognitive, sensory, and motor dysfunctions due to neurologic disease of the nervous system [7, 34]. Music Supported Therapy and Melodic Intonation Therapy were proposed to induce plastic changes in the brain in terms of functional connectivity and neural reorganization in the sensorimotor cortex, [7, 35, 36, 37] as well as in white matter tracts [7, 38].

Schneider et al. [7, 39, 40] showed that Music Auditory Stimulation leads to improvements in speed, precision and smoothness of movements in fine as well as gross motor skills in stroke patients. Further, music therapy has a positive effect on mood in patients with stroke [7, 8, 41, 42]. Rhythmic Auditory Stimulation can enhance gait ability [7, 43, 44, 45], flexibility [7, 42], as well as functional motor performance of the paretic upper extremity [7, 46]. Despite the growing body of scientific evidence in favour of the use of music therapy in neurorehabilitation, there is a need for better understanding of the impact of the therapy programs incorporating music and rhythm.

The novel main finding of study by Särkämö et al. was that regular self- directed music listening during the early post-stroke stage can enhance cognitive recovery and prevent negative mood [8]. Specifically, after the 2-month intervention period, patients who listened to their favourite music 1–2h a day showed greater improvement in focused attention and verbal memory than patients who listened to audio books or received no listening material. Moreover, patients who listened to music also experienced less depressed and, to a lesser extent, confused mood after the intervention than patients who received no listening material. Since the patient groups did not differ in demographic and clinical variables at the baseline or in antidepressant medication and rehabilitation received during the intervention, and since any non-specific effects of therapeutic attention were controlled for, these differences observed in cognitive recovery can be directly attributed to the effect of listening to music. Furthermore, the fact that most of the music also contained lyrics, would suggest that it is the musical component (or the combination of music and voice) that plays a crucial role in the observed recovery of these cognitive functions [8].

Music-Supported Therapy (MST). This therapy involves repetitive exercises using musical instruments (MIDI piano and electronic drums) in order to train fine and gross motor functions in patients suffering from mild to moderate upper limb paresis after a stroke. Over the past five years, MST has been applied to two large samples of acute stroke patients, reporting relevant improvement in motor performance [21, 37, 38, 39].

In the Amengual et al. study, was observed significant motor gains accompanied by plastic changes in chronic stroke patients who were tested before and after 20 sessions of music supported therapy (MST). Of note, they found increased motor cortex excitability in the patients' affected hemisphere after training, an association between changes in the motor cortex representation on the injured hemisphere and improved performance of diadochokinetic movements with the affected upper limb. These results suggest that MST can drive task-dependent cortical reorganization in stroke patients in the chronic stage [21].

The study Vileneuve et al. provides preliminary evidence indicating that a piano training program combined to home practice is feasible and can lead to meaningful improvements in manual dexterity, finger movement coordination, and functional use of upper extremity in chronic stroke survivors. For the first time, it was also demonstrated that MST training effects are maintained at a 3-week follow-up. This unique intervention, which targeted finger movement coordination, engaged the participants in an individually tailored and highly motivating program. It has the potential to be self-managed and pursued on the long term, outside the rehabilitation setting, and lead to further and sustainable improvements in upper extremity function [47].

MIT is a hierarchically structured treatment that uses intoned (sung) patterns to exaggerate the normal melodic content of speech by translating prosodic speech patterns (spoken phrases) into melodically-intoned patterns using just two pitches11. MIT contains two unique elements that set it apart from other, non-intonation-based therapies: 1) the melodic intonation (singing) with its inherent continuous voicing, and 2) the rhythmic tapping of each syllable (using the patient's left hand) while phrases are intoned and repeated. Another important characteristic of MIT is that, unlike many therapies administered in the chronic phase that involve one to two short sessions per week, MIT engages patients in intensive treatment totaling 1.5 hrs/day, five days/ week until the patient has mastered all three levels of MIT, usually 75–80 or more sessions [38].

Using an adapted version of melodic intonation therapy (MIT), Zipse et al. treated an adolescent girl with a very large left-hemisphere lesion and severe nonfluent aphasia secondary to an ischemic stroke [48]. At the time of her initial assessment 1.25 years after her stroke, she had reached a plateau in her recovery despite intense and long-term traditional speech-language therapy (approximately five times per week for more than one year). Following an intensive course of treatment with their adapted form of MIT, her performance improved on both trained and untrained phrases, as well as on speech and language tasks. These behavioral improvements were accompanied by functional MRI changes in the right frontal lobe as well as by an increased volume of white matter pathways in the right hemisphere. No increase in white matter volume was seen in her healthy twin sister, who was scanned twice over the same time period. This case study not only provides further evidence for MIT's effectiveness, but also indicates that intensive treatment can induce functional and structural changes in a right hemisphere fronto-temporal network [48].

The contribution of singing to melodic intonation therapy has been considered as crucial by the inventors of the treatment. Singing was supposed to stimulate cortical regions in the right hemisphere with homotopic location relative to left language areas.

In the Stahl et al. study, they aimed to assess the relative importance of various factors related to singing for speech production in 17 non-fluent aphasics [49]. Contrary to some opinion, their results suggest that singing may not be decisive for speech production in non-fluent aphasics. Divergent findings in the past could very likely be a consequence of the acoustic setting, insufficient control of syllable duration or language-specific stress patterns. However, their results indicate that rhythm may be crucial, particularly for patients with lesions including the basal ganglia. It is noteworthy that lesions within the basal ganglia accounted for 450% of the variance related to rhythmicity. Their findings suggest that benefits typically attributed to melodic intoning in the past may actually have their roots in rhythm [49].

CONCLUSIONS

Music therapy is used in the small part of rehabilitation after stroke. In view of the proven role of music therapy in improving the health of people after stroke it should be used as one of the permanent elements of stroke rehabilitation.

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