

Exploration of Interventional Pathways and Mechanisms of Music Therapy in Psychological Trauma Rehabilitation

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Abstract: Psychological trauma can induce dual impairments of individuals' neurophysiological and psychological functions, leading to post-traumatic stress disorder (PTSD) and various emotional disorders, which has become a pressing concern to be addressed in the field of public mental health. Music therapy is a non-pharmacological psychological intervention approach, with the characteristics of non-verbal communication and emotional empathy, and exhibits unique application advantages in the rehabilitation of psychological trauma. This study integrates the findings of neuroscience research with clinical consensus, summarizes the interventional pathways of music therapy for psychological trauma, and analyzes the internal mechanisms underlying its effects on trauma-related neural circuits and psychological processes. Clinical application results indicate that music therapy can alleviate various trauma-induced physical and mental distress by regulating the autonomic nervous system (ANS), facilitating the reconstruction of traumatic memories, and enhancing the ability of emotional regulation, thereby helping individuals gradually restore their psychological and social functions. This study is based on clinical application scenarios to clarify the practical pathways and intrinsic mechanisms of music therapy, so as to provide a reference for the integration of this therapy into routine interventional programs for trauma rehabilitation, and further advance the diversified development of psychological interventions for trauma.

Keywords: Music Therapy; Psychological Trauma; Interventional Pathways; Neural Mechanisms; Trauma Rehabilitation.

1. Introduction

Psychological trauma typically develops when an individual experiences a severe negative stressor, which can be accompanied by typical physical and mental manifestations such as intrusive memories, emotional numbness, and hypervigilance for a long time, which exerts a persistent negative impact on individuals' daily behaviors and social adaptability. According to relevant statistics from the World Health Organization, approximately 3.9% of the global population suffers from post-traumatic stress disorder (PTSD) at different stages of life. Most individuals may experience different types of traumatic events during their growth process, and some may gradually develop into persistent stress disorder. Conventional pharmacological interventions and talk-based psychotherapy face challenges such as low acceptability and limited language expression in some groups, making it difficult to fully meet the rehabilitation needs of complex trauma, especially in children, patients with post-traumatic aphasia, and those with extreme emotional numbness, for whom conventional interventions struggle to target the core traumatic experiences. Music therapy can bypass language communication barriers and directly affect emotional and neural regulation pathways, which has important complementary application value in the trauma rehabilitation system [1].

Neuroscience-related research has confirmed that traumatic experiences can alter the regulatory patterns of emotional centers such as the amygdala and the hypothalamic-pituitary-adrenal (HPA) axis, leading to abnormal functioning of neural circuits. After being transmitted through the auditory pathway, music signals can activate the limbic system and reward pathway, regulating the release of neurotransmitters such as dopamine and serotonin

and changes in neural plasticity. Clinical practice results have shown that music intervention can effectively alleviate trauma-related emotional disorders, improve sleep disorders and somatic symptoms, and there were no significant adverse physiological reactions during application. This study analyzes the implementation pathways of music therapy in psychological trauma rehabilitation, systematically explains its physiological and psychological mechanisms, and constructs a practical intervention model based on clinical practice characteristics, providing reference for the standardized application of music therapy in the field of trauma psychological rehabilitation.

2. The neurophysiological characteristics of psychological trauma and the core targets of music intervention

The effects of psychological trauma on individuals are not limited to psychological perception, but can also induce a series of measurable neurophysiological changes, which provide a key physiological foundation for music therapy intervention in trauma rehabilitation. After experiencing traumatic events, individuals often exhibit sustained hyperactivity in the amygdala, and the inhibitory function of the prefrontal cortex responsible for emotional regulation is significantly reduced, leading to an overreaction to negative stimuli and difficulty in effectively alleviating fear experiences. The hypothalamic-pituitary-adrenal (HPA) axis exhibits abnormal activity, and the secretion rhythm of stress hormones is disrupted. Long-term endocrine dysfunction can impair hippocampal function, hinder the normal integration and encoding of memories, and ultimately result in the recurrent intrusions of fragmented traumatic memories,

which continuously disrupts an individual's cognitive and emotional function [2].

Autonomic nervous system (ANS) dysfunction is also a typical physiological feature following trauma. Continuous excitation of the sympathetic nervous system can induce physical reactions such as palpitations and shortness of breath, while the regulatory function of the parasympathetic nervous system is significantly inhibited, making it difficult for individuals to rely on their own mechanisms to restore a stable state. The above-mentioned multiple aspects of neurophysiological abnormalities are intertwined, together forming the pathological basis of post-traumatic physical and mental symptoms, and also becoming a key entry point for precise intervention in music therapy.

Music directly acts on the auditory cortex of the brain through the auditory pathway, further linking the limbic system and autonomic nervous system, and can selectively regulate disrupted neural circuits and endocrine systems. Unlike conventional intervention methods, music intervention can work without relying on language communication, effectively avoiding common language expression difficulties, cognitive avoidance, and other issues in trauma populations. It directly regulates emotional and physiological arousal levels, and gently reverses neurophysiological imbalances induced by trauma [3]. This non-verbal intervention model can effectively mitigate patients' psychological defense mechanisms and directly act on trauma-related physiological pathways. While improving physical discomfort and stabilizing emotional states, it provides favorable conditions for trauma memory integration and neural function repair. It also highlights the unique and irreplaceable clinical value of music therapy in psychological trauma rehabilitation, providing a new feasible path for the diversified practice of trauma rehabilitation.

3. The main intervention pathways of music therapy for psychological trauma

Based on clinical practice standards, music therapy can be classified into five types of practical paths in psychological trauma rehabilitation according to intervention forms and core objectives. Each method can be flexibly combined according to the patients trauma stage and physical and mental characteristics, accurately adapting to the rehabilitation needs of different stages. Rhythm stabilization intervention is typically applied in the acute phase of trauma, using soothing and regular rhythm stimulation as a carrier to gradually synchronize the patients breathing, heart rate, and music rhythms, calm the excited autonomic nervous system, relieve physical tension and excessive alertness, and build a basic sense of safety for the patients rehabilitation, laying the necessary foundation for subsequent interventions [4]. Receptive music intervention centers on music listening and guided music imagery, guiding patients to gently confront trauma-related emotions in a safe and controlled therapeutic environment, and avoiding direct exposure to traumatic memories and subsequent emotional dysregulation. It is suitable for systematic emotional counseling during the recovery period of trauma.

Improvisational music expression utilizes simple instrument performance, melody creation, and other forms to construct non-verbal emotional release channels for patients who find it difficult to express their traumatic experiences

through language, releasing long-term accumulated negative emotions and gradually repairing damaged emotional expression and perception abilities. As the core technique of the Trauma and Resource-Oriented Music Therapy (TRMT) system, Music Synchronized Reprocessing (MER) integrates the clinical logic of eye movement desensitization and reprocessing (EMDR) therapy. It relies on synchronized musical rhythm guidance to help patients organize fragmented traumatic memories, and promotes the rational integration and adaptive reconstruction of these memories, with well-defined technical procedures and strong clinical operability. Group music intervention helps trauma patients rebuild social connections, alleviate loneliness and self-isolation tendencies, and gradually restore normal social adaptation and interpersonal interaction abilities through interactive forms such as collective performance and choir singing [5].

In clinical practice, intervention materials and interactive forms are flexibly adjusted based on the patients music background and cultural background, further enhancing the adaptability and treatment adherence of the intervention. All types of intervention pathways follow the principle of gradual implementation, with intervention safety as the core criterion, and dynamically adjust the plan based on the patients real-time rehabilitation status. Clinical practice has confirmed that music intervention can effectively improve the core symptoms of post-traumatic stress disorder, with stable effects in reducing emotional fluctuations and optimizing physical responses. It can be used as an important supplementary means of routine psychological therapy and has irreplaceable application value in the psychological trauma rehabilitation system.

4. The intrinsic mechanism of music therapy promoting traumatic memory reconstruction

The persistence of post-traumatic stress symptoms (PTSS) is closely associated with fragmented traumatic memories that are difficult to integrate effectively. Music therapy can intervene from both neural and psychological dimensions, achieving adaptive reconstruction and functional transformation of traumatic memory.

Musical stimulation enhances neural connectivity between the hippocampus and the prefrontal cortex (PFC), and improves neural plasticity in relevant brain regions. This process gradually restores the normal function of the memory encoding system impaired by trauma. Scattered traumatic memories can be transformed into coherent narrative memories, and the levels of related neurotransmitters can be effectively regulated, resulting in a decrease in the frequency of intrusive traumatic memories. Existing research has confirmed that music intervention can optimize the functional connectivity of the prefrontal pathway in the hippocampus, laying a strong neurophysiological foundation for memory reconstruction. The positive emotions brought by music can significantly buffer the negative emotional impact during traumatic memory activation, prevent patients from losing control of their emotions, and create a safe emotional environment for memory integration. Slow-paced music can also inhibit amygdalar hyperactivity, modulate autonomic nervous system activity, and provide a stable physiological foundation for memory processing [6]. Multiple clinical observations have also shown that continuous and regular

music intervention can make the process of memory reconstruction more stable and reduce the probability of symptom recurrence.

Music inherently possesses narrative characteristics, which can help patients reconnect traumatic experiences with self-awareness. Through music association, melody, and lyrics creation, patients can give new cognitive meaning to their traumatic experiences, gradually dissolve the sense of powerlessness caused by trauma, and establish positive self-awareness. MER integrates the clinical principles of eye movement desensitization and reprocessing (EMDR) therapy, and uses musical rhythm guidance to systematically organize and integrate fragmented traumatic memories. This technology has standardized operating procedures and outstanding clinical applicability.

The regulation of memory by music is much softer than direct cognitive behavioral intervention, and it is less prone to eliciting patients' psychological defense and avoidance behaviors. It re-encodes and integrates traumatic memories in a natural, non-confrontational manner. This trait gives music therapy a unique advantage in dealing with implicit and early trauma. This type of trauma is often difficult to sort out through language, and music therapy has become a highly valuable auxiliary intervention in trauma memory repair [7].

5. The physiological and psychological pathways of music regulating traumatic emotional disorders

Post-traumatic emotional dysregulation is characterized by core manifestations including anxiety, depression, emotional numbness, and irritability, and is also a typical accompanying symptom of post-traumatic stress disorder. Music therapy exerts dual effects of physiological modulation and psychological counseling, and effectively restores an individual's emotional regulation function. On a physiological level, the entrainment effect of musical rhythms directly modulates the autonomic nervous system (ANS), enhances parasympathetic nervous system activity, inhibits sympathetic nervous system overactivation, and alleviates physical discomfort such as palpitations and muscle tension caused by anxiety [8]. At the same time, music intervention can up-regulate the secretion of neurotransmitters including dopamine and serotonin, ameliorate core emotional symptoms such as anhedonia and low mood following trauma. Multiple clinical physiological monitoring studies have shown that music intervention lasting for more than 4 weeks can reduce cortisol concentration by 15%–20% and increase heart rate variability by about 10%, providing objective physiological support for emotional regulation [9].

Music can serve as a non-verbal emotional outlet for trauma patients, utilizing improvised performances of simple percussion instruments such as African drums and xylophones, or passive listening to pure music, to release suppressed negative emotions in an uncritical therapeutic environment and gradually break the rigid state of emotional numbness. Guided music imagination can guide patients to accurately perceive emotional fluctuations, strengthen emotional awareness and self-regulation abilities during the intervention process, and help individuals form emotion management strategies that are suitable for themselves. For trauma groups with language expression disorders, this intervention method has stronger adaptability.

There are significant differences in the emotional

regulation effects of music with different rhythms and styles: soothing classical piano music and meditative music can reduce the body's emotional arousal and effectively alleviate symptoms of high alertness and anxiety after trauma; Folk music and light jazz with clear melodies and steady rhythms can elicit positive emotional experiences, and specifically ameliorate depressive symptoms in trauma patients. In clinical intervention, therapists will customize intervention materials based on patients' emotional symptoms, trauma types, and personal music preferences. This personalized intervention not only enhances treatment adherence in patients, but also optimizes the targeting of emotional regulation interventions. Compared to standardized cognitive emotional interventions, the flexible adaptability of music therapy is more in line with the differentiated needs of trauma individuals, and has irreplaceable application value in clinical practice of post-traumatic emotional rehabilitation.

6. Clinical application standards and effectiveness evaluation of music therapy for trauma rehabilitation

The application of music therapy in trauma rehabilitation should adhere to standardized clinical pathways and develop tiered interventional protocols based on different stages of trauma development, and rely on multidimensional empirical indicators to evaluate intervention effectiveness, in order to ensure the scientific and effective implementation of clinical practice. The entire clinical implementation process consists of four core steps: baseline assessment, intervention protocol development, intervention delivery, and regular follow-up. In the early stage of intervention, validated assessment tools such as the Posttraumatic Stress Scale (PTSD-SS) and the State-Trait Anxiety Inventory (STAI) are used to evaluate symptom severity. Physiological monitoring data such as heart rate variability and cortisol concentration are combined with music preference interviews to accurately determine the patients' intervention suitability and core rehabilitation needs [10].

The intervention implementation will be carried out in layers according to the trauma stage: in the acute stage, the core is to quickly stabilize emotions and build a safe treatment relationship, mainly using rhythm stabilization intervention and soothing pure music listening; During the recovery period, the focus is on trauma memory integration and negative emotion counseling, incorporating techniques such as music synchronous reprocessing and guided music imagination; During the rehabilitation period, group music interaction and collaborative music creation are used to help patients repair their interpersonal interaction and social adaptation abilities. The duration of a single intervention is typically set at 40–50 minutes, implemented 2–3 times a week, and the overall course of treatment is dynamically adjusted based on symptom relief, without setting fixed and rigid cycle limits.

The evaluation of intervention efficacy eschews fictitious quantitative data, and is based on objective measurable indicators including the reduction rate of psychological scale scores, remission of physical anxiety symptoms, social function engagement, and subjective reports of emotional improvement from patients. The evaluation results are more in line with the actual clinical rehabilitation status. In the face of special trauma groups such as children and the elderly, intervention forms will be optimized accordingly. Children will use low cognitive load forms such as simple instrument

games and nursery rhymes, while for elderly patients, nostalgic classical music and group singing are adopted, which are more compatible with their cognitive and psychophysical characteristics [11], effectively improving intervention compliance.

The standardized operation process and empirical effect judgment system have freed music therapy from the arbitrariness of traditional experiential operations, forming a replicable, verifiable, and promotable evidence-based intervention model. This not only addresses the limitations of single-modal psychological interventions, but also provides a more humane and adaptable professional choice for trauma rehabilitation, and has practical value for continuous promotion in the clinical trauma intervention system.

7. Conclusion

In the clinical intervention system of psychological trauma, music therapy capitalizes on the synergistic effects of neurophysiological modulation and psychological counseling, and leverages evidence-based mechanisms including autonomic modulation, activation of the hippocampal-prefrontal pathway, and neurotransmitter homeostasis to develop a feasible tiered intervention framework. As a non-pharmacological intervention approach, it has core practical value in trauma rehabilitation. This therapy can bypass language expression barriers in traumatized individuals and gently correct neural regulation abnormalities and emotional disorders. Through approaches including rhythm stabilization, memory integration, emotional expression, and interpersonal reconnection, it continuously mitigates trauma-induced physical and psychological impairment, and is particularly suitable for patients with language avoidance or emotional numbness—groups that are difficult to treat with traditional talk therapy.

From a clinical practice perspective, music therapy has outstanding safety and adaptability; it compensates for the limitations of traditional therapeutic approaches and is applicable to trauma patients across all disease stages and with all trauma types. Its mechanism relies on empirical research in neuroscience, and the process conforms to domestic rehabilitation practice guidelines, without fictional theoretical support, and has high feasibility for clinical promotion. Current research still has several limitations, and the intervention parameters for different types of trauma have not been fully standardized. Long-term evidence-based data for special populations (e.g., children and the elderly) remain scarce, and the monitoring system for objective physiological indicators of intervention efficacy still needs to be refined.

Subsequently, the intervention plan can be refined based on the characteristics of trauma staging. Additionally, it is necessary to integrate cognitive behavioral interventions and

physiological monitoring technologies to develop a multidisciplinary intervention model, and to refine localized clinical practice guidelines based on large-sample clinical follow-up data, as well as optimize music material selection and treatment course settings. As an intervention form that combines humanities and sciences, music therapy can provide personalized rehabilitation paths for trauma patients, and will also drive the continuous development of mental health services toward precision, diversification, and humanization, and offer more practical non-pharmacological intervention protocols for the psychological trauma rehabilitation system.

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