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The Efficacy and Feasibility of Music Therapy for Post-Traumatic Stress Disorder: An Evidence-Based Review of Recent Case Study and Clinical Trials

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Abstract. With psychology moving towards an integrated biological-psychological-social model, music therapy has become an important new direction in treating post-traumatic stress disorder because it can adjust neuroplasticity and work across different cultures. Based on related experiments and clinical studies from the past five years, this paper assesses whether music therapy is possible and effective for post-traumatic stress disorder, as well as its limits. It looks into three areas including neural mechanisms, suitability for different groups and technology integration. This study focused on three parts: the neurophysiological mechanism that music therapy affects post-traumatic stress disorder's main symptoms, music therapy's differential effect for people of different ages, cultures, and with different traumas, and the way of handling ethical issues from mixing technologies. This study found out that music therapy provides a special and non-verbal way to rebuild the connection of damaged nerves, as well as regain the ability of self-regulate. The factors that plasticity and the functional organization of the brain from different ages, and the understanding, expression of music from different cultures influence the effect of music therapy. The final integrated findings reveals that music therapy needs to change from a general treatment to a precise music medicine model. It is very useful as a helper to main treatments but has limits when used alone and its future development will depend on closer work between neuroscience, cultural anthropology, and artificial intelligence.

Keywords: Music therapy, Post-Traumatic Stress Disorder, efficacy, feasibility

1. Introduction

Nowadays, psychotherapy has evolved from a single therapeutic approach to a more integrated biological–psychological–social model. According to research, the trend is mainly driven by three directions: neuroscientific mechanisms, mathematical techniques, and the cross culturally adaptable interventions. One of the most closely investigated cutting-edge treatment methods is music therapy.

Music therapy is an intervention method that uses music as a medium. Through the guidance of professional music therapists, it helps clients regulate psychological states, improve emotions, or promote the recovery of physical and mental functions through musical activities. It is widely applied in fields including mental health, rehabilitation medicine and special education. Under this

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background, music therapy, a representative of nonverbal therapy technique, has received significant attention in the field of psychological trauma treatment. This is probably due to its cross-cultural adaptability, and its capacity to modulate plasticity of neurons. Crucially, music therapy is no longer seen just as a supplementary intervention. It is now a standalone and effective treatment. These changes show the innovation of psychology. Music therapy has now turned to the stage of evidence-based medicine, with its therapeutic benefits substantiated through rigorous scientific inquiry.

Post-traumatic stress disorder (PTSD) is a stress-related condition that develops following exposure to life-threatening or intensely distressing events, such as war, natural disasters, violent crimes or serious accidents. People with PTSD mainly have three symptoms: reliving the traumatic event, being more alert than usual, and avoiding things related to the trauma or feeling emotionally numb. Statistics show that about 4% of people worldwide will have PTSD at some point in their lives [1]. More than a third of these patients develop long-term symptoms that can last for decades. Their risk of suicide is six times higher than that of the general population, and over 50% also suffer from depression or substance abuse. Certain demographic and psychological factors are associated with higher vulnerability to PTSD. High-risk populations include military veterans, refugees, and survivors of natural disasters. The core innovative point of this article depends on its embrace of a case-based analysis structure. It achieves significant progress by systematically integrating high-quality case studies that published over the past five years. The analysis will be structured into three key sections by exploring underlying mechanisms, integrating case findings and discussing arguments. This approach provides a comprehensive task of both the feasibility and effectiveness of music therapy in treating PTSD.

2. Exploring underlying mechanisms

2.1. Neuroscience

Contemporary neuroscience research has found out key mechanisms underlying the efficacy of music therapy in treating Post-Traumatic Stress Disorder (PTSD), mainly through its moderating effects on the dysfunctional connectivity within the brain's triple network system. The brain’s triple network system is a model that describes the dynamic interaction between three large-scale brain networks that are fundamental to cognition. Perception, and consciousness. Rather than working in isolation, these networks constantly communicate and regulate each other. Vinod Menon proposed a theoretical framework pointing out that patients with PTSD show a synergistic imbalance among the salience network, the central executive network, and the default mode network. The salience network constantly monitors both internal bodily sensations and external stimuli to identify the most important information at any given moment. The central executive network, which is engaged for active, goal-directed thinking, requires focused attention and effort. The default mode network is most active when people are not focused on the outside world that mind is wandering. For example, activities like daydreaming and envisioning the future. Music therapy interventions, by engaging these networks across dimensions of time, frequency, and space, can potentially rebuild the disrupted balance [2].

2.2. Memory & emotion

The main advantage of music therapy different from the traditional therapy is its realization of traumatic memory reconstruction through non-threatening sensory channels [3]. The non-threatening sensory channels refer to the pathways through which human bodies receive external information,

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such as sounds and smells, but without tension, fear or defensive reactions. So, the core is allowing individuals to receive signals in a relaxed state. A randomized controlled trial revealed the female patient suffered from PTSD, receiving Group Music and Imagery (GrpMI) exhibit a unique phenomenon of“emotional-cognitive decoupling”in the Script-Driven Imaginary task [4].

The phenomenon of emotional-cognitive decoupling refers to a psychological state in which an individual’s emotional experience becomes temporarily separated from their cognitive appraisal of the event or stimulus that triggers it [5]. When the patient listened to the identical and individualized music while remembering the traumatic events, the fMRI demonstrates that there was a 32% reduction in amygdala activation intensity as well as a 58% increase in interior cingulate cortex (ACC) activity. The amygdala is a core structure of the brain’s limbic system. Its primary functions are processing emotional information such as fear and anxiety, participating in the formation and retrieval of emotional-driven behavioral responses. The functions of interior cingulate cortex are associated with emotion regulation, pain perception, decision making and self-awareness. For example, a person experiences anxiety, activity in this cortex may has changes. What is meant is that music creates a“safe container”which enables patients to reprocess the traumatic memories in the state of low anxiety [6].

3. Integrating case findings

3.1. The impact of age

Recent research indicates that age influences responses to music therapy. A quasi-experimental study on kidnapping victims showed a different effect in the responses of children and adults to music and art therapy [6].

In the children group (aged 5-12), the intervention combining interactive media music games showed a 73.2% reduction in PTSD symptoms, which was substantially higher than the 36.1% reduction observed in the art therapy group. The design overcomes the limitation of children’s language development through metaphorical expression. For example, the "music shield" game helps participants symbolically build safe boundaries. Notably, the study used eye-tracking technology to quantify treatment engagement, and found that children's visual attention duration in music games (386 seconds) was much longer than that in traditional talk therapy (127 seconds), indicating that the advantage of children’s attention improvement is prominent [6]. However, the adult group (aged 18 and above) performed better in art therapy (containing music and painting), with a symptom relief rate of 68.5%, contrasted to only 41.7% in pure music intervention. This difference origins from the variation in prefrontal lobe maturity since adults have developed abstract thinking abilities and can integrate traumatic narratives from multiple artistic expressions [6].

Due to these facts, ages significantly impacted the effect of individuals receiving music treatment which verified the matching degree between the characteristics of different age groups and different music therapies.

3.2. Suitability of music therapy

Different types of mental disorders require different appropriate treatments. Case studies have found that music therapy has a significant effect in treating various disorders.

The “Gaze-Contingent Musical Reward Therapy” (GC-MRT) developed by Columbia University reconstructs attention patterns based on the principles of operant conditioning. In this protocol, when social anxiety disorder patients gaze at neutral faces, their favorite music is played; when they gaze

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at angry faces, the music stopped. Hence, an "attention shift-positive reinforcement" connection has established. The result showed that the attention duration of the experimental group on threatening stimuli decreased by 42%, and the curative effect lasted until 3 months after the intervention [7].

According to this study, it shows that the music therapy has a great suitability which can design specific intervention strategy based on different mental illnesses. It is a helping method for psychological treatment that has a strong adaptability and empirical support.

4. Outlining controversies from case findings

About how music therapy impacts the brain, researches have different opinions. Some researchers find that music can changes the connection mode of the brain., like enable better communication between the brain region which controls emotion (the anterior cingulate cortex) and the brain region that generates fear (amygdala) [8]. In the experiment of Aalborg University, after the trauma survivors took 12 weeks of group music therapy, something changed as they faced trauma memories, the activity of the amygdala dropped by 32%. At the same time, the activity of the anterior cingulate cortex increased by 58% [6]. This type of change is similar to what happens with traditional therapy. It shows that music can rebuild the brain's pathways for controlling emotions. Others who come out different result that consider the effect might due to psychological suggestion. The study from Columbia University found that when the control group used "fake music intervention" (lack of therapeutic support), 27.6% of participants still reported that their symptoms had improved. This was not significant differ to the early effects of real music group [9]. Meaning that the research design should be stricter to reduce the placebo effect.

The question why music therapies from different regions of the world has different effect on people in different regions is mainly because the difference in cultural genes, which refers to the fundamental differences that exist among different social groups in terms of their deep-seated values, worldviews and the code of conduct. A study by Guangzhou Medical University selected participants from both China and Canada to listen Five-element music (a traditional Chinese five-tone scale) and Western classical music [10]. Comparing the reactions it was found that after listening to Five-elements music, the Chinese group's anxiety scale scores decreased 39% more than when they listened to Western music. However, the Canadian group showed no difference in their responses to these two types of music. In fact, the temporal lobe (the part of the brain that handles auditory processing) of Chinese participants reacted more actively to the five-tone scale [10].This is because the music activated their traditional cultural memories. On the other hand, western music needed the extra use of the prefrontal lobe (the part related to cognitive load) to decode unfamiliar symbols, which requires more mental resources. Since, it directly proves that cultural background affects how the brain perceives art, which is cultural neuroaesthetics.

5. Conclusion

This paper assesses the neural mechanisms, clinical effectiveness, differences between different population groups and applicable boundaries of music therapy in treating post-traumatic stress disorder (PTSD) by systematically integrating high-quality studies from the past five years.

The findings show that music therapy achieves therapeutic effects through multiple mechanisms, including regulating neuroplasticity, optimizing physiological functions, and enhancing cross-cultural adaptability. By improving the connectivity of brain and the emotional regulation, music therapy addresses core dysfunctions in patients better than traditional treatments. Its clinical value lies in its advantages in addressing the core pathology of PTSD. It breaks through the language

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limitations of traditional therapies. Furthermore, music therapy offers a non-threatening and accessible form of intervention which can reduce the barrier to treatment, particularly in high-risk populations such as who has suicide ideas may avoid traditional communication therapy.

However, the paper identifies three limitations. First, there is a bottleneck in independent application of music therapy. The development of music therapy is not very mature, and the interfering factors are hard to control that might influence the effect in real treating conditions. So, is more suitable as an auxiliary method and combine with other systematic methods except in specific cases. Second, there is a dilemma in standardization, as music is an abstract artistic form, evaluating its therapeutic effects needs to combine multimodal indicators. Third, since there are lots of differences between individuals, so there is a challenge in personalization that needs a hierarchical intervention model based on age, cultural background, and trauma type needs to be established.

This paper can offer some insights to relevant groups. Clinical workers should use MT as part of a multi-dimensional treatment system, and technology developers should embed ethical review mechanisms in AI-assisted music therapy.

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