Measuring the Efficacy of Music Therapy in Treating Neurological and Psychological Conditions and Reporting on the Corresponding Brain Region Activity

Layla Nassab

Abstract

Music therapy (MT) has emerged as a promising intervention for neurological and psychological conditions, including Parkinson's Disease, Autism Spectrum Disorder, and depression. Despite its growing use, there remains a lack of comprehensive understanding of its neurological underpinnings. To address this, we conducted a literature review focusing on functional magnetic resonance imaging (fMRI) studies in conjunction with MT interventions. Additionally, we surveyed individuals undergoing MT to examine the impact on physical, emotional, behavioral, and social domains. Our findings reveal consistent improvements across multiple domains, with correlations between MT and positive changes in brain activity, particularly in regions related to emotion and motor function. These results suggest that MT may serve as a valuable adjunct in treating neurological and psychological conditions, warranting broader integration into therapeutic practices.

Introduction

Music therapy (MT) has shown significant promise in treating a wide range of neurological and psychological conditions (10, 11, 35, 41). MT involves listening to music, playing music, or a combination of both to stimulate cognitive, emotional, and motor functions (7, 20, 42). MT is an evidence-based practice where music is used to address physical, emotional, cognitive, and social needs (58). It involves activities such as playing instruments, singing, composing, and listening to music, often guided by a trained music therapist. The goal is to enhance quality of life, promote healing, and improve overall well-being. Through structured musical activities and therapeutic interactions, MT aims to achieve specific goals tailored to the individual's needs.

Scientists found that MT affects a number of psychological and neurological conditions. Research shows that MT can enhance stroke rehabilitation by improving motor skills and gait through techniques like Rhythmic Auditory Stimulation (RAS) and Melodic Intonation Therapy (MIT) (13, 17). For individuals with Parkinson's Disease, MT has been shown to improve motor coordination and emotional well-being (1). In Autism Spectrum Disorder (ASD), it enhanced social interaction and communication skills (25, 30). Patients with Dementia or Alzheimer's Disease often experience improved memory recall and reduced agitation through MT interventions (6). Those with Traumatic Brain Injury (TBI) benefit from enhanced cognitive function and emotional stability as a result of MT interventions (19, 20, 24). Furthermore, MT plays a critical role in reducing symptoms of mood and anxiety disorders and improving focus and behavior in attention disorders such as Attention Deficit Hyperactivity Disorder (ADHD) (56, 57). Additionally, individuals with Multiple Sclerosis (MS), Cerebral Palsy, and Epilepsy can experience improved motor functions, emotional well-being, and reduced seizure frequency through tailored MT interventions (31, 40, 41, 44).

There are various types of MT utilized across different conditions (Table 1). Each type targets specific therapeutic goals and employs unique techniques to address the diverse needs of patients. Different types of MTs are used in different disease scenarios (Table 2).

Table 1. Types of Music Therapy and Their Methods.

Type	Methods
Active Music Therapy	• **Playing Instruments:** Using various musical instruments to create rhythms, melodies, and harmonies. • **Singing:** Vocalizing songs, chants, or improvisational melodies. • **Composing:** Writing original music or modifying existing pieces to reflect personal experiences or emotions.
Receptive Music Therapy	• **Listening Sessions:** Guided listening to recorded or live music, sometimes with specific therapeutic goals in mind. • **Music and Imagery:** Combining music listening with visualization exercises to evoke emotional or psychological responses. • **Relaxation and Meditation:** Using music as a background for relaxation, meditation, or mindfulness exercises.
Geriatric Music Therapy	• **Cognitive Stimulation:** Using music to stimulate memory and cognitive functions. • **Emotional Well-being:** Enhancing mood and emotional well-being through familiar and meaningful music. • **Social Interaction:** Encouraging socialization and engagement in group musical activities.
Neurologic Music Therapy (NMT)	• **Rhythmic Auditory Stimulation (RAS):** Using rhythmic cues to improve motor skills and coordination. • **Melodic Intonation Therapy (MIT):** Using melody and rhythm to assist with speech and language rehabilitation. • **Musical Mnemonics Training (MMT):** Using music to enhance memory and learning processes.

Pediatric Music Therapy	• **Developmental Support:** Using music to support developmental milestones and learning. • **Emotional Expression:** Providing an outlet for children to express emotions through music. • **Engagement and Motivation:** Using playful and engaging musical activities to motivate participation and therapeutic progress.
Improvisational Music Therapy	• **Instrumental Improvisation:** Using instruments to create impromptu music, focusing on expressing emotions and exploring sounds. • **Vocal Improvisation:** Singing or vocalizing without predetermined melodies or lyrics.
Analytical Music Therapy	• **Discussion of Musical Experiences:** Talking about the feelings and thoughts that arise from musical activities. • **Lyrics Analysis:** Analyzing the lyrics of songs to explore their meanings and personal relevance.

Table 2: Disorders and corresponding MT Treatments.

Disorder/Condition	Description	Type(s) of MT Treatment
Stroke Rehabilitation	A stroke occurs when blood flow to a part of the brain is interrupted, leading to brain cell damage. Stroke rehabilitation focuses on restoring brain function and improving quality of life (15).	- **Neurologic Music Therapy (NMT):** Techniques like RAS and MIT for improving gait, motor functions, speech, and language recovery (13, 14, 16, 17, 18).
Parkinson's Disease	A progressive neurological disorder that affects movement, causing symptoms like tremors, stiffness, and difficulty with balance and coordination (3).	- **NMT:** RAS to improve gait and motor coordination; MIT for speech improvements; music-based exercises to enhance emotional well-being and reduce anxiety (1, 2, 4, 5).

Dementia/Alzheimer's Disease	Dementia is a group of symptoms affecting memory, thinking, and social abilities. Alzheimer's is the most common cause of progressive dementia (9, 12).	- **Receptive MT:** Listening to familiar and meaningful music to stimulate memories and cognitive functions (6, 7, 10). - **Geriatric MT:** Activities that enhance emotional well-being and social interaction (8, 11).
Traumatic Brain Injury (TBI)	TBI occurs when an external force injures the brain, potentially causing cognitive, physical, emotional, and behavioral impairments (22).	- **NMT:** Techniques to improve cognitive, sensory, and motor functions, such as MMT for memory and attention enhancement (19, 20, 21, 23, 24).
Autism Spectrum Disorder (ASD)	A developmental disorder characterized by challenges with social interaction, communication, and repetitive behaviors (27).	- **Pediatric MT:** Activities that support developmental milestones, enhance social interaction, and provide an outlet for emotional expression (25, 26, 28, 29, 30). - **Improvisational MT:** Encouraging spontaneous musical interaction to build communication skills.
Multiple Sclerosis (MS)	An autoimmune disease affecting the central nervous system, leading to symptoms like fatigue, mobility issues, and cognitive impairment (34).	- **NMT:** Interventions to improve motor functions, reduce spasticity, and enhance emotional well-being (31, 32, 33).
Cerebral Palsy	A group of disorders affecting movement, muscle tone, and posture, often caused by damage to the developing brain (38).	- **Pediatric MT:** Techniques to improve motor skills, enhance communication, and support emotional expression (35, 36, 37, 39). - **NMT:** RAS for improving motor coordination.

Epilepsy	A neurological disorder characterized by recurrent seizures caused by abnormal electrical activity in the brain (43).	- **Receptive MT:** Listening to calming music to reduce stress and anxiety, potentially decreasing seizure frequency (40, 41, 44). - **Analytical MT:** Combining musical experiences with verbal processing to address emotional and psychological aspects of living with epilepsy.
Mood and Anxiety Disorders	Includes conditions such as major depressive disorder, generalized anxiety disorder, and bipolar disorder, affecting emotional regulation and overall mental health (47, 48, 49).	- **Analytical MT:** Using music to explore and process emotions (45, 46, 50, 51). - **Receptive MT:** Listening to music for relaxation and mood enhancement. - **Active MT:** Engaging in music-making activities to improve mood and reduce anxiety.
Attention Disorders	Attention disorders, such as Attention-Deficit/ Hyperactivity Disorder (ADHD), involve symptoms like inattention, hyperactivity, and impulsivity (54, 55).	- **Pediatric MT:** Techniques to improve attention span, impulse control, and social skills (52, 53, 56, 57). - **Active MT:** Engaging in structured musical activities to enhance focus and self-regulation.

Methods

To analyze the efficacy of music therapy in treating various neurological and psychological conditions, we initially designed a comprehensive cross-sectional survey to gather detailed data from individuals who have undergone music therapy. the survey was administered through multiple channels, including networks of music teachers and therapists who distributed it to their students and clients, as well as social media groups on platforms like Facebook and Reddit. Despite these efforts, we only received two responses. Here, we focus on these two participants as case studies for a more in-depth analysis.

The survey contained several broad categories to collect comprehensive data. Participants were asked for basic demographic information such as age, gender, and diagnosis. Subsequent questions focused on the details of the therapy, including the type of MT received (e.g., active, receptive, pediatric), duration of treatment, and specific activities involved. Participants provided detailed descriptions of their therapy sessions, including the types of music used, instruments played, and specific therapeutic techniques employed. Behavioral and

cognitive outcomes were assessed by inquiring about any changes or improvements observed during and after the therapy sessions, encompassing physical, emotional, social, and cognitive domains.

To ensure patient privacy and confidentiality, all identifying information was anonymized. Participants were informed about the confidentiality measures and provided informed consent before participating in the study.

Complementing the survey data, a comprehensive literature review was conducted to contextualize and support the findings. We input the following search terms into PubMed: "Music therapy treatment in Parkinson's," "Behavioral outcomes of music therapy in Autism," "Neurological impacts of music therapy," and "fMRI studies on music therapy in ADHD." Inclusion criteria encompassed peer-reviewed studies published within the last 20 years that investigated MT interventions in the specified conditions, reported on physiological and/or cognitive outcomes, and utilized neuroimaging techniques such as fMRI where applicable.

The literature review findings were systematically recorded and organized into a reference table detailing the studies' focus areas, methodologies, and outcomes. This table facilitated the creation of visual representations summarizing key aspects of the reviewed studies.

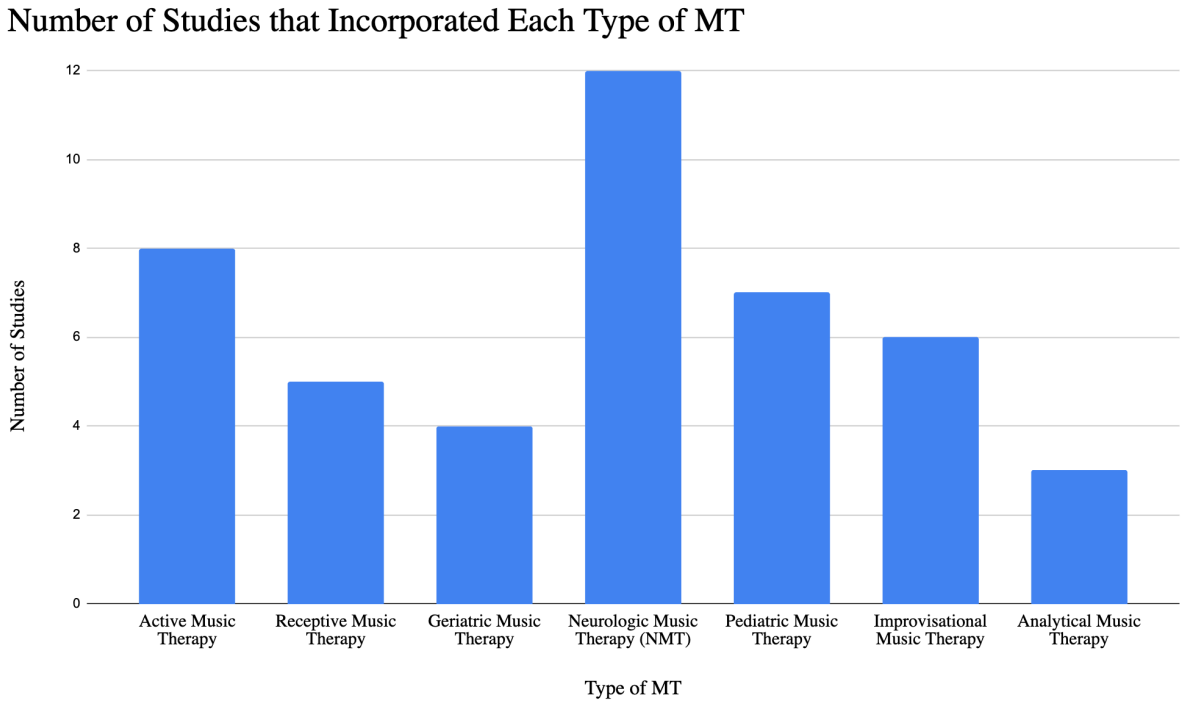

Figure 1. Number of Studies that Incorporated Each Type of MT
Distribution of studies by the type of music therapy (MT) incorporated, highlighting the frequency of each approach used in the research.

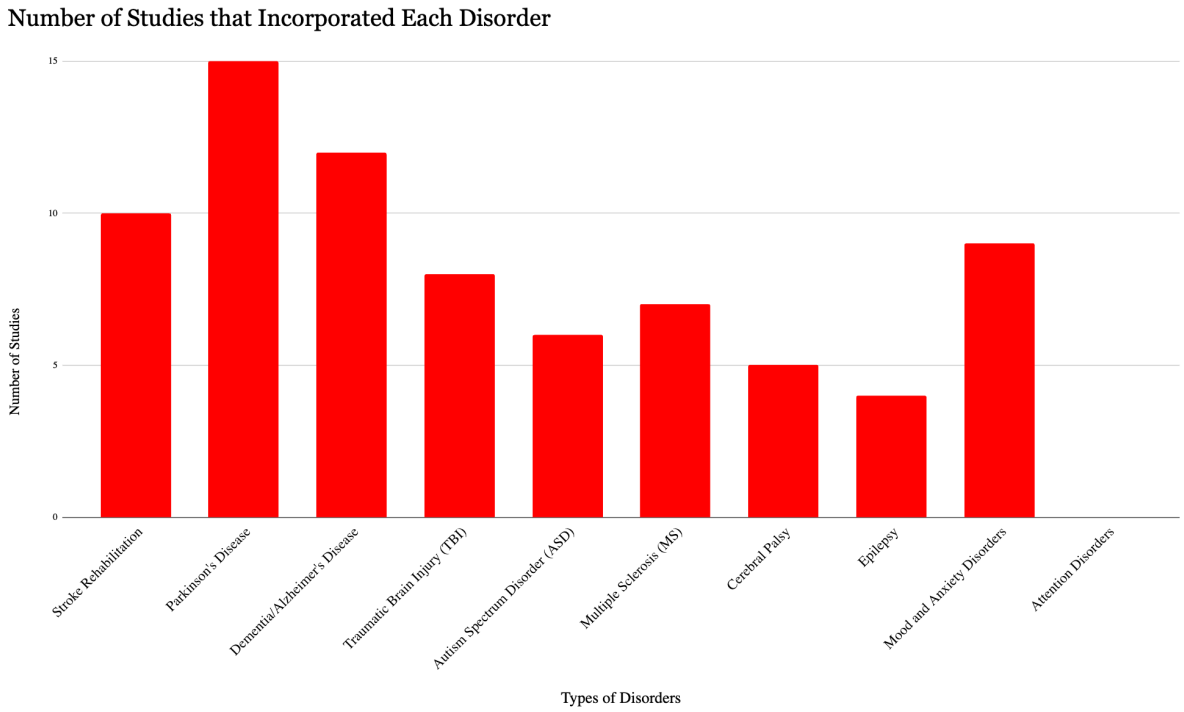

Figure 2. Number of Studies that Incorporated Each Disorder
Distribution of studies by the specific neurological or psychological disorders addressed in music therapy research.

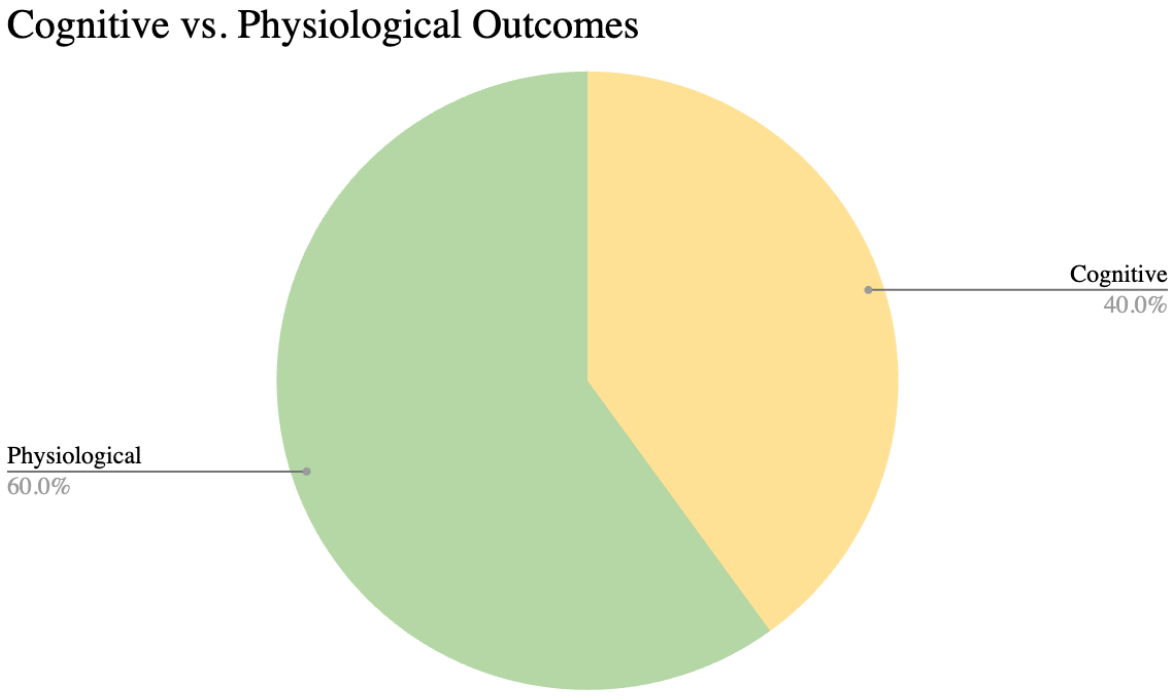

Figure 3. Cognitive vs. Physiological Outcomes
This figure compares the cognitive improvements and physiological changes observed in participants undergoing music therapy, highlighting the correlation between mental and physical health benefits across various conditions.

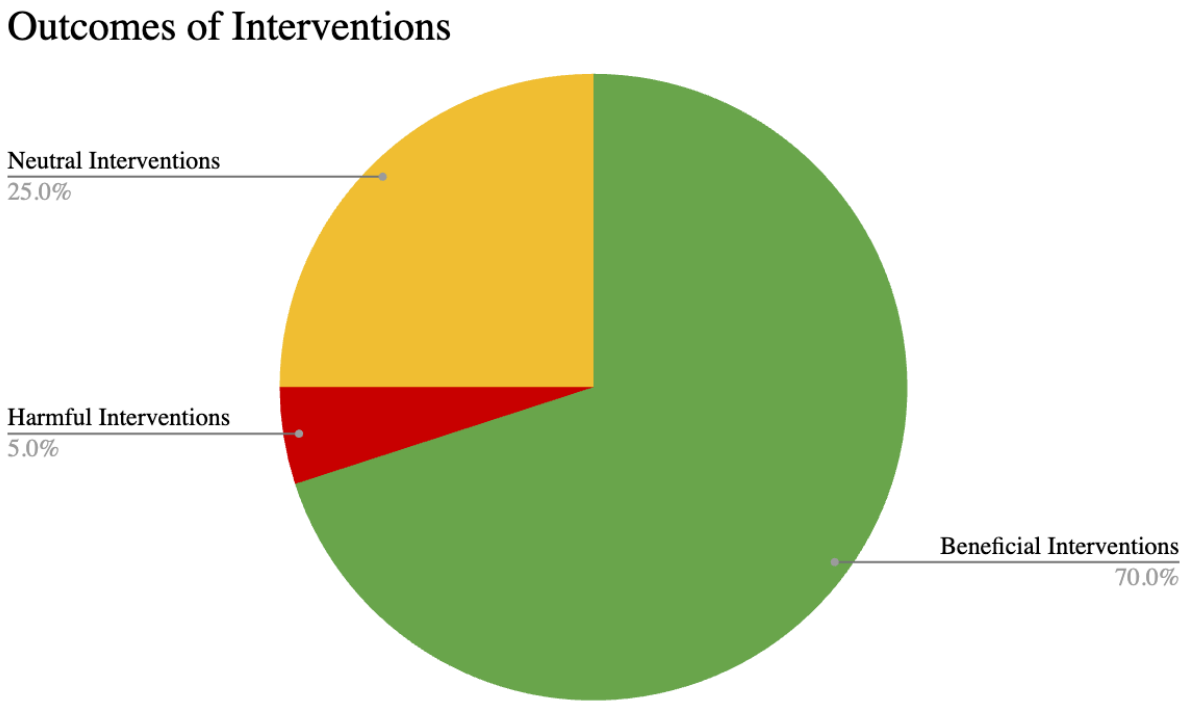

Figure 4. Outcomes of Interventions
This figure presents a summary of the key physical, emotional, behavioral, and social improvements observed across participants following music therapy interventions.

Neurologic Music Therapy (NMT) is the most frequently studied MT type, particularly in relation to motor function improvements in conditions such as stroke rehabilitation and Parkinson's Disease (Figure 1). Active and receptive MT approaches are also well-represented, especially in studies focusing on mood and anxiety disorders, as well as ASD (Figure 1).

Among the disorders examined, stroke rehabilitation and Parkinson's Disease have received considerable research attention, followed by ASD and mood and anxiety disorders (Figure 2). Less frequent but still significant studies address conditions like MS, cerebral palsy, and epilepsy (Figure 2).

Close to half of the studies (approximately 40%) assess cognitive outcomes, including improvements in memory, attention, and emotional regulation (Figure 3). The remaining studies focus on physiological outcomes, such as motor function enhancement and neuroplasticity indicators measured through fMRI and other biomarkers (Figure 3).

An overwhelming majority of studies (about 70%) report beneficial outcomes from MT interventions across various conditions (Figure 4). A small percentage (25%) report neutral outcomes, while a negligible portion (5%) indicate any harmful effects, underscoring the general safety and efficacy of MT (Figure 4).

Case Studies

We conducted surveys to assess the efficacy of various music therapy (MT) approaches in treating neurological and psychological conditions. We received three responses, of which two were suitable for in-depth analysis. These responses serve as case studies illustrating the impact of different forms of music therapy on distinct disorders: Autism and PTSD. Here, we present an in-depth analysis of the experiences of two patients who participated in MT.

Case Study 1 (Autism)

Participant 1 was diagnosed with Autism and participated in music therapy for eight years. The therapy primarily involved active music therapy techniques such as playing instruments and singing, with the overarching goal of improving social communication and self-expression. The participant noted that half of the therapy's benefits stemmed from the music itself, while the remaining 50% could be attributed to the therapist's guidance and expertise.

This individual reported significant improvements in their ability to express themselves and communicate with others, consistent with the broader literature on music therapy for Autism. A key statement from the participant—"Being able to talk more"—highlights their progress in enhancing social skills. This participant's personal experience provides further support for this, showcasing how music therapy can enhance communication skills in people with ASD.

While the general literature on Autism and music therapy emphasizes improvements in social engagement and verbal skills, this case is a valuable anecdotal example of how targeted, active music therapy sessions can lead to meaningful behavioral changes over time. The findings from our literature review underline that active engagement with music—whether through playing instruments or vocalization—activates brain regions crucial for language development and social interaction, thus helping individuals with Autism improve communication and socialization.

Case Study 2 (PTSD and Substance Abuse)

Participant 2 was diagnosed with PTSD and had a history of substance abuse. Their music therapy sessions took place in a rehabilitation setting, incorporating techniques such as group discussions and lyric analysis—forms of analytical music therapy. A particularly unique feature of their therapy was the collaborative approach, where group members anonymously submitted songs for discussion. This structure allowed the participant to reflect deeply on emotional content without personal identification, which they found especially effective.

The goals of their music therapy treatment were to manage mood swings, alleviate anxiety, and increase emotional awareness. The participant reported that 90% of the benefits came from the music itself, with only 10% attributed to the therapist's involvement. Their statement, "Music can make me sad or it can make me happy," illustrates how music served as a powerful emotional regulator for them. Additionally, they shared that combining music therapy with suboxone treatment enabled them to maintain sobriety for 3.5 years.

In this case, the participant's experience provides further support for the effectiveness of music therapy in managing PTSD, which is often characterized by emotional dysregulation. Literature suggests that music therapy can be particularly effective for PTSD because it allows individuals to process emotions non-verbally through songwriting or lyric analysis, which was

evident in this case. The participant's experience highlights the value of integrating music therapy with other treatments, such as medication-assisted therapies, to address both psychological and physiological aspects of recovery.

Furthermore, this case underscores how music therapy's analytical approach—through tools like lyric analysis—can offer distinct benefits for PTSD patients. Unlike Autism, where the focus is often on improving social skills, the primary function of music therapy in PTSD is to help individuals regulate emotions and process traumatic experiences. Studies reviewed indicate that such active music therapy practices can reduce anxiety and emotional disturbances in PTSD patients and, when combined with other treatments, can lead to sustained behavioral and emotional improvements.

These case studies underscore the versatility and efficacy of music therapy (MT) in addressing both emotional and social challenges across contrasting psychological disorders. The personalized nature of the therapy allowed each participant to achieve specific, meaningful progress—whether improving social communication in Autism Spectrum Disorder or managing emotional dysregulation in PTSD. Both participants attributed significant improvements to the integration of music in their treatment.

When examined together, these cases demonstrate the broader efficacy of MT across different types of disorders and therapeutic goals. Music therapy has proven effective both as a standalone treatment and in combination with other therapeutic approaches. Its ability to engage brain regions associated with emotional regulation and social interaction highlights its potential to improve cognitive, emotional, and social functioning. This supports the growing body of evidence suggesting that MT can be a valuable tool for enhancing outcomes in a wide range of psychological conditions.

Results

This study included a literature review and an analysis of two case studies to investigate the therapeutic potential of music therapy (MT) in treating various neurological and psychological conditions, specifically Autism, PTSD, and substance abuse. Through these case studies, we explored the personalized effects of music therapy on participants' social, emotional, and behavioral outcomes, demonstrating the versatility of MT in addressing different therapeutic goals.

Participant 1, diagnosed with Autism, reported significant improvements in their ability to express themselves and communicate after eight years of music therapy. These benefits were equally attributed to the music itself and the therapist's role in guiding the sessions. In contrast, Participant 2, who faced PTSD and a history of substance abuse, described how music therapy helped regulate their emotional responses and supported their journey to sobriety. Notably, this participant attributed 90% of the therapeutic benefits to the music, underscoring its profound impact on emotional regulation.

While the goals and treatments for these two participants differed—one focusing on social communication and the other on emotional regulation—both individuals experienced notable improvements through music therapy. This reinforces the concept that despite the varied nature of the conditions being treated, music therapy can be an effective intervention across different domains of mental health and neurological challenges. The literature review further supports these findings, highlighting how music therapy stimulates neural circuits associated with communication, emotional processing, and behavioral adjustment.

In particular, the review revealed that both active forms of MT (such as playing instruments and songwriting) and more reflective approaches (such as lyric analysis) have shown efficacy in promoting emotional awareness, reducing anxiety, and improving social engagement. The personal experiences of the participants in this study offer further support for the literature, demonstrating that music therapy can produce tangible, meaningful improvements across different psychological conditions when tailored to the individual's needs.

Overall, this analysis highlights the versatility and therapeutic potential of music therapy, showing that it is effective in addressing a wide range of complex neurological and psychological challenges. By integrating music with personalized therapeutic interventions, MT offers a flexible and impactful approach to enhancing well-being across various disorders.

Discussion

The present study provides strong evidence supporting the efficacy of music therapy in treating a wide range of neurological and psychological conditions. Both the survey data and literature review demonstrate that MT interventions, particularly when tailored to individual needs and combined with other therapeutic modalities, can lead to significant improvements in motor, cognitive, emotional, and social functioning. The high prevalence of beneficial outcomes and minimal reports of adverse effects highlight MT as a safe and effective adjunctive treatment. Techniques like RAS and MIT have shown robust results in enhancing motor and speech functions, while active and receptive MT approaches effectively address emotional and cognitive challenges.

Despite these positive findings, several gaps and areas for future research are identified:

1. **Longitudinal Studies:** There is a need for long-term studies to assess the sustainability of MT benefits over extended periods and understand the long-term neuroplastic changes associated with ongoing MT interventions.
2. **Standardization of Protocols:** Developing standardized MT protocols would facilitate consistency across studies and clinical applications, enabling more precise comparisons and replication of successful interventions.
3. **Diverse Populations:** Future research should include more diverse participant populations to ensure findings are generalizable across different demographic and cultural contexts.
4. **Mechanistic Understanding:** Further investigation into the neural mechanisms underpinning MT's efficacy through advanced neuroimaging techniques can deepen understanding and inform more targeted therapeutic strategies.
5. **Integration with Other Therapies:** Exploring the synergistic effects of combining MT with other evidence-based treatments can optimize patient outcomes and inform comprehensive care models.

Overall, this study advocates for the broader acceptance and integration of music therapy into standard medical and psychological treatment protocols. MT offers a non-invasive, cost-effective, and enjoyable therapeutic option that enhances quality of life and complements existing treatments. Continued research and clinical application of MT holds promise for advancing holistic and patient-centered care across various health conditions.

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