



A Review of Music Therapy in the Treatment of Autism Spectrum Disorder

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Abstract. Autism Spectrum Disorder (ASD) is a complex neurodevelopmental condition characterized by a wide range of challenges in social communication, behavior, and sensory processing. This comprehensive review evaluates how music therapy benefits individuals with Autism Spectrum Disorder (ASD) by investigating its impact on enhancing social interaction, alleviating anxiety and stress, and facilitating emotional regulation. Moreover, we delve into the relevant brain regions and mechanisms underlying the therapeutic effectiveness of music therapy in ASD. While promising, the field of music therapy in ASD faces certain limitations and challenges. By considering the interplay between psychology and cognitive neuroscience, this review aims to provide a deeper understanding of the potential of music therapy as a harmonizing intervention for individuals on the autism spectrum.

Keywords: autism, music therapy, positive outcomes, brain regions, mechanism.

1 Introduction

As the advent of increasing frequency of autism spectrum disorder (ASD), its formal research enters the sight of the public. ASD is a complex neuro developmental disorder with a broad range of characteristics and symptoms. From academic perspective, ASD describes a constellation of early-onset in social communication

deficits, repetitive sensory-motor movements, and sensory abnormalities which are influenced by genetic factors and other contributing factors [1]. Public attention towards this disorder significantly increased in the 21st century. Over recent decades, ASD prevalence has grown. A review of 71 studies since 2012 indicated a median global prevalence of 100 in 10000, showing considerable variation [2]. Recent years have seen a steady increase in prevalence, with rates rising from 1 in 149 to 1 in 54 within merely 10 years from 2008 to 2018[3]. With increased observation among acquaintances, colleagues, or relatives' children, it's more likely to encounter a child with ASD, reflecting its growing prevalence.

Academic research in the field of ASD has explored various intervention and treatments to address the challenge, including behavioral therapies, speech and language therapies, pharmacological interventions, and support programs. For instance, supplementing Sulforaphane and utilizing Antipsychotic drugs or Antidepressants have shown some therapeutic benefits. A trial indicated that sensorimotor enrichment could mitigate symptoms of autism on children aged 3 to 6 years old[4]. However, these strategies may have side effects like conventional drugs do or be tedious for young children. This has led to hypothesis that music therapy may stimulate the brains of individuals with ASD, encouraging more typical behaviors.

2 Using Music Therapy in Autism

Music therapy is an established therapeutic approach that has been applied to deal with various psychological and developmental disorders, encompassing ASD. In 1994, Edgerton's systematic investigation into music therapy, involving 11 children aged six to nine, suggested its effectiveness in enhancing communicative behaviors in children with ASD [5]. Prior to music therapy, individuals with autism often struggle to perceive others' emotion, hindering their response to external stimuli. Nevertheless, with improvised music, children with autism could build interaction with parents or caregivers in daily lives[6]. But such evidence is not abundant though it's plausibly convincing. In 2015, The U.S. National Center for Autism formally acknowledged the efficacy of music therapy as a clinical intervention for treating individuals with autism, highlighting its significance in this field. In April 2018, an orchestra of musicians with autism performed at Beijing's National Theatre Music Hall, further

demonstrating the achievements of music intervention training[7]. Therefore, music therapy's effectiveness is authoritatively proved.

Numerous studies have provided empirical evidence for the efficacy of music therapy in treating ASD. While varying results, music therapy consistently yields positive outcomes in the following areas.

2.1 Improved Social Interaction.

Music therapy can enhance social engagement, helping individuals with autism develop important social skills. A study divided 27 children with mild to moderate autism symptoms into experiment group (13 children) and control group (14 children). After participating in a music therapy program, the experiment group got an incredibly boost in social skills and reacted to their caregivers more intimately, in contrast to the control group, assessed by the Statistics Package for Social Science[8].

2.2 Reduced Anxiety and Stress.

Music has a calming effect and can alleviate anxiety, which is often associated with autism. Music therapy, like other treatments, aims to reduce maladaptive behaviors and increasing adaptive ones in individuals with autism. Music therapy serves as a supplementary tool in conjunction with other methods to mitigate symptoms by alleviating stress and anxiety. According to a study conducted in China, listening to calming music for only 30 minutes prior to a surgery reduced levels of stress hormones in the bloodstream and mitigated physiological manifestations of anxiety[9]. Additionally, a case study on rhythmic entrainment demonstrated its effectiveness in reducing anxiety-related disruptive behaviors in an autistic 11 year-old [10]. A key advantage of this approach is its accessibility, as it requires no specialized knowledge of music, thus broadening its applicability to a wider patient range.

2.3 Better Emotional Regulation.

Music therapy can help individuals with autism manage their emotions and express themselves in more constructive ways. In his seminal book “The Anthropology of Music”, Merriam (1964) discussed music’s role in eliciting emotions[11]. Bhagyaveni,notes the essential role of music in regulating emotions in the workplace.

For example, Rap music possesses the power to calm emotions, uplift spirits, and instill a hopeful and constructive mindset. While playing melancholic tunes can evoke a sense of nostalgia and creativity among the staff, serene and melodious melodies have the power to regulate their emotional states. During times of stress, playing calm and soothing music at the workplace has the ability to alleviate employees' restlessness and reduce tension. Under stress, the human body typically exhibits reactions like increased breathing, heart rate, blood sugar, blood pressure, hormone secretion, and nerve excitement. Conversely, autism patients hold the long-term stress which harm their physiological health. Assisting in stress mitigation and maintaining stable, positive emotions are crucial in autism treatment. Hence, incorporating music therapy into treatment strategies is essential.

3 Relevant Brain Regions and Mechanisms Underlying the Effectiveness of Music Therapy in Autism

Drawing from the fields of psychology and cognitive neuroscience, this section summarizes the relevant brain regions and mechanisms associated with the effects of music therapy on individuals with ASD. The article explores how music therapy activates reward pathways, modulates emotional processing, engages auditory and sensory processing areas, stimulates the social brain network, aids in sensory integration, promotes brain plasticity, enhances executive functioning, and impacts language processing. By understanding these neurobiological mechanisms, this review aims to shed light on the potential benefits of music therapy as an intervention for individuals with ASD.

3.1 Activation of Reward Pathways

Music therapy has been shown to activate reward pathways in the brain, including the nucleus accumbens[12]. This activation of the brain's reward system can enhance motivation and engagement in individuals with ASD, making them more receptive to therapeutic interventions[13][14].

3.2 Mirror Neuron System

Musical activities such as rhythm coordination and imitation stimulate the brain's mirror neuron system, especially in the superior temporal gyrus and frontal lobe areas. This helps enhance imitation skills and social learning in individuals with ASD[14].

3.3 Emotional, Auditory and language Processing

Music therapy has the ability to regulate the way emotions are processed in the brain by influencing specific regions like the amygdala and the prefrontal cortex. This can be particularly relevant for individuals with ASD, as emotional expression and regulation are often challenging areas. Music can serve as a non-verbal channel for emotional expression and understanding[15].

The primary auditory cortex and associated brain regions are crucial for processing auditory information. Music therapy, through rhythm and melodic patterns, engages and stimulates auditory processing areas in the brain. This can help individuals with ASD improve their auditory discrimination and processing skills[16].

Some studies have shown that music therapy can enhance language processing skills, and this is associated with activation in language-related brain regions, such as Broca's area and Wernicke's area. Improving language abilities is essential for individuals with ASD to enhance communication and social interaction[13].

3.4 Brain Plasticity and Social Brain Network

By facilitating neuroplastic changes, music therapy holds the capability to induce transformative impacts on the brain. Through repeated musical exercises and interventions, the brain can adapt and rewire itself. This is particularly significant for individuals with ASD, as it may aid in skill acquisition and the development of new neural pathways[17].

Music therapy has been linked to the activation of the brain's social network, which includes regions like the anterior cingulate cortex, the superior temporal sulcus, and the mirror neuron system. These areas are involved in recognizing and understanding social cues, and music therapy may enhance social interaction skills in individuals with ASD by engaging these brain regions[18].

3.5 Executive Functioning and Sensory Integration

Music therapy can impact executive functions such as attention, working memory, and cognitive flexibility. Brain regions involved in executive functions, including the prefrontal cortex, are engaged during music therapy sessions. Strengthening these cognitive skills can benefit individuals with ASD in various aspects of daily life[19].

The parietal cortex and thalamus are involved in processing sensory input, contributing to sensory integration within the brain. Music therapy, with its rich sensory experiences, can help individuals with ASD improve sensory integration and reduce sensory sensitivities[20][21].

4 Limitations and Challenges

Though music therapy for autism appears highly effective, it faces certain challenges. The first challenge is the difficulty in measurement. The academic field of music therapy hasn't figured out a formal assessment tool to quantify effect of music therapy or an unified criterion. Apart from a study [8] that used Statistics Package for Social Science to assess increasing social skills in autistic children, other cited research often lacks robust statistical evaluation, providing only abstract descriptions, especially in emotion and social testing. Many studies use terms like "reduce anxiety", "more effective", or "boost social skills" without quantitative backing or measurement standards, reducing their scientific credibility. Moreover, another limitation is lacking of long-term study. Proponents of music therapy argue for its significant short-term benefits in treating autism, but opponent question the longevity of these effects, noting a lack of research confirming their durability. Undoubtedly, long-term study are crucial for understanding the lasting effect and sustainability of music therapy intervention throughout an individual's lifespan. The prevalent issue is that experiments often last only a few days. Another essential point is heterogeneity of ASD. The vast individual differences in ASD make it complex to determine the universal effectiveness of music therapy, since different symptoms and levels of functioning required tailored therapeutic approaches. An extensive review revealed a lack of music therapy treatments specifically tailored for individual patients. Researchers concentrate more on music therapy's theoretical validity instead of category for individuals.

Consequently, there must be reasonable solutions. To address the lack of assessment tools, experts ought to be encouraged to develop Standardized Treatment Protocols, using larger samples for more accurately assessment across diverse ASD populations, including standardized graph or particular data to measure efficacy levels. Additionally, to evaluate long-term effects, researchers could conduct more longitudinal studies, building upon cross-sectional research. Finally, for individualized treatment, there should emphasize tailored approaches that consider the specific needs and preferences of the patient, thereby enhancing the effectiveness of the therapy. This personalization can be facilitated through detailed assessments and the integration of technology for tailoring therapeutic approaches to the specific profiles of participants. Specifically, integrating modern technologies, like utilizing virtual reality, artificial intelligence or even mobile apps could innovate music therapy approaches and assess their impact on individuals with ASD. Researchers should explore the potential of technology-driven interventions in addressing the unique challenges faced by individuals with autism, making therapy more engaging and adaptable to different settings.

The future of music therapy in autism research lies in collaborative efforts among professionals from various disciplines, including psychologists, music therapists, neuroscientists, educators, and clinicians. Interdisciplinary collaboration can facilitate a holistic understanding of how music therapy impacts cognitive, emotional, and social domains in individuals with autism.

5 Conclusion

In conclusion, the incorporation of music therapy as part of the treatment for Autism Spectrum Disorder presents a hopeful opportunity to enhance the quality of life for those affected by ASD. Music therapy has demonstrated its capacity to enhance social interaction skills, reduce anxiety and stress levels, and promote better emotional regulation among individuals on the autism spectrum. From a cognitive neuroscience perspective, the involvement of brain regions such as the mirror neuron system, limbic system, and prefrontal cortex highlights the complex neurobiological mechanisms through which music therapy exerts its therapeutic effects.

However, it is essential to acknowledge the limitations and challenges inherent in this field. Methodological variability across studies, the need for more extensive and controlled research designs, and the heterogeneity of the autism spectrum pose

significant challenges. Additionally, the generalization of skills acquired during music therapy sessions to daily life remains an area of concern.

As we move forward, interdisciplinary collaboration between psychologists, music therapists, neuroscientists, and educators will be crucial in advancing our understanding of music therapy's potential. Further research, particularly large-scale randomized controlled trials, personalized interventions, and the integration of technology, will help address these limitations and unlock the full potential of music therapy as a harmonizing intervention for individuals with ASD. Ultimately, the pursuit of this promising therapeutic avenue underscores the importance of holistic and evidence-based approaches in the treatment of ASD, aiming to improve the well-being and quality of life of individuals across the autism spectrum.

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