Neurological Interactions Between Improvisational Music Therapy and Children with Autism Spectrum Disorder

Scarlett Huang

Abstract

It has been found that music therapy is an effective intervention for children with autism spectrum disorder (ASD) [15]. Improvisational music therapy serves as an effective intervention as it targets certain neural mechanisms, such as the mirror neuron system and the amygdala, through the use and response of musical cues [17]. This literature review presents research that supports the imitation and understanding of body language as well as rhythmic patterns in both music and movement, and how this can lead to enhanced and improved activity in both social and motor behavior in autistic children. The implication for this review is to provide a clear understanding and raise awareness of how the inclusion of music therapy can become a promising treatment targeting the amygdala as well as the mirror neuron system, and how music therapy can effectively improve the quality of life of children with ASD.

Introduction

Composer Hans Christian Anderson is reputed to have said that "where words fail, music speaks." Children with autism spectrum disorder (ASD) may be able to express their emotions, build meaningful relationships, and dissolve social barriers through music [25]. A neurodevelopmental disorder known as ASD is characterized by difficulties with social interaction, restrictive and repetitive behaviors, and problems processing sensory information [1]. Many academic studies have been undertaken to examine the possible advantages of using musical therapies in ASD treatment [25].

According to the Centers for Disease Control and Prevention [3], 1 in 36 children have an ASD diagnosis in 2020, which is an increase from decades past. There is widespread agreement that despite the interactions of several variables leading to the origin and etiology of this disorder, ASD is dictated by an accumulation of specific brain processes [6]. In order to shed light on the mechanisms by which improvisational music therapy affects these brain functions and helps children with ASD improve their social communication and motor skills, this literature review will present a variety of studies on music therapy and its' effects on the mirror neuron system and the amygdala as well as their findings. The review will address the research question: "How does the integration of improvisational music therapy affect the mirror neuron system and the amygdala, and how does it foster the development of social communication and motor skills in children with ASD?" Additionally, the review will also offer a comprehensive analysis of the advantages and restrictions of music therapy for people with ASD and give recommendations for further research.

Therapies for Autism Spectrum Disorder

In the middle of the 20th century, Thayer Gaston, a notable scientist, was the first to postulate that music can encourage emotional expression and introspection, provoking a variety of mental reactions including enhanced self-awareness and the growth of interpersonal

relationships [10]. Gaston's work has had a considerable impact on the field of psychotherapy and opened up new opportunities for the use of music in clinical settings [10]. To address social communication and motor deficiencies linked to ASD, a range of therapy techniques have been employed, such as occupational and speech therapy. However, because of their predominant focus on individual skill-building instead of group communication skills, offering a more person-centered approach, they may not adequately address the complex social and motor issues that children with ASD often struggle with [19].

Improvisational music therapy (IMT), a clinically-proven method used by trained and certified music therapists, has emerged in contrast to conventional interventions like occupational and speech therapy [23]. IMT enables people to facilitate emotional expression, communication, and social interaction without the restriction of predetermined social structures, barriers, or rules [13]. This therapeutic technique operates on the premise that music, through uses of rhythmic qualities and emotional articulation, has the ability to engage and stimulate the mirror neuron system. Consequently, this can result in advancements in overall motor and social interactions among individuals diagnosed with ASD [4]. Hence, in order to achieve desirable outcomes in therapy, it is beneficial to establish effective communication with the neural networks responsible for social communication and motor skills [12]. When the ability to engage in verbal or nonverbal interactions is hindered, it is evidenced to be a fundamental impairment in ASD, impeding connections with others [1]. Additionally, children with ASD commonly have delays or impairments in a variety of abilities involving fine and gross motor coordination, with an impact on social communication as a prime example [12]. As a result, it is essential to recognize that these delays and impairments can influence social communication problems, which is developed through the mirror neuron system. For scientists to truly understand social cognition, the mirror neuron system has become a prominent area of research .

Mirror Neuron System

The mirror neuron system (MNS), which is critical for interpreting and replicating movements, is activated both when a person performs an action and when they see another person performing a comparable action [20]. This mirroring process helps people understand the underlying motivations and emotional states that govern the conduct of others, fostering the growth of social awareness and empathy [4].

Atypical mirror neuron systems, which are characterized by decreased stimulation and interconnectivity and, consequently, social communication, are typically seen in children with ASD [21]. However, they further showed that IMT has the power to improve the activity and connectivity of the mirror neuron system, hence removing barriers to social contact.

To improve motor abilities, especially in those with ASD, observation of others' activities and mental movement imitation are critical. The activation of mirror neuron networks during motor learning through means such as motor execution, simulation, verbalization, and observation, is highlighted by a considerable body of research that supports this idea. For example, non-invasive measures of brain activity and functional brain imaging have shown such motor learning. Following observation or mental simulation, various brain areas, including the inferior parietal lobe (IPL), ventral premotor cortex (VPC), and the inferior frontal gyrus (IFG), have been shown to become activated [7]. These areas are crucial components of the

multisensory action-observation system, allowing people to retrain damaged motor skills [4]. IMT uses sensory initiatives to engage the auditory, visual and motor systems of the brain. The use of IMT on these visual and motor systems necessitates responsiveness and real-time correction, which activates the mirror neuron system [16]. Children engaged in IMT are given the opportunity to watch and copy the motions and gestures of their therapists and peers through musical interactions, developing their mirror neuron circuitry [21]. Additionally, the multifaceted nature of music therapy improves the integration of auditory, visual, and motor information, resulting in a more thorough awareness of both a person's motor abilities and their environment [9]. Through active participation in music-making, children with ASD engage their mirror neuron networks, enabling subsequent execution of real-life or imagined activities [16]. Through this procedure, the treatment helps children with ASD grow and enhance their motor abilities.

According to the "broken mirror" theory, people with autism have deficiencies in their MNS, which is in charge of understanding and imitating other people's activities [4]. According to this idea, people with ASD experience difficulties with social interaction, communication, and motor skills, and these core social and cognitive deficits is what the MNS is responsible for. Chan & Han's [4] research provides insight into the brain correlations of action-observation in people with ASD, proposing that an altered MNS response is seen in people with ASD as evidenced by the increased activity reported in the right IFG and left supplementary motor area (SMA) during biological motions. This suggests that the standard mirroring system allowing internalization and replication of observed activities may be damaged. This could prevent children with ASD from accurately learning motor skills and imitating motions. In addition, a subgroup analysis based on the presence or absence of emotional components during action observation in Chan & Han's [4] research reveals unique patterns of heightened activation in individuals with ASD. The researchers found that the processing of non-emotional actions may be substantially altered in people with ASD, according to the amplification of the left IPL and left SMA during non-emotional action perception. On the other hand, the rise in right IFG activity following emotional action illustrates the impact of behavioral indicators related to emotional actions that individuals with ASD display or respond to in the MNS.

These findings propose that emotional signals may modify MNS activity, therefore accounting for the emotional expressiveness and empathy difficulties in ASD. Provided that music naturally induces emotions, it can act as a medium for emotional expression and communication [22]. This is made apparent by the fact that when listening to happy or sad music, "individuals with ASD show activations in cortical and subcortical brain regions that are known to be deficient in this patient group with regard to nonmusical emotional stimuli" [12]. Music can stimulate the emotional component of MNS through various music modalities of therapy including singing, playing instruments, improvisation, or music listening, expanding the regulation and control of emotions in children with ASD [22]. For the purpose of trying to fully grasp how sensory deficits may give rise to the identified shortcomings in social interaction and motor skills, prospective studies may explore a relationship between the altered MNS response and sensory processing variations in people with ASD.

Within the context of ASD, the notion of shared affective motion experience (SAME) offers a novel take on the likely implications of IMT on the MNS and its resulting consequences on social interaction in children with ASD. Recent studies have developed an empirical

framework designed to highlight the role of the MNS in both physical and emotional responses to music, giving birth to the premise of SAME. The SAME model, as proposed by Molnar-Szakacs et al. [16], contends that one's understanding of musical sound transcends the purely auditory experience, as it also reflects the expressive motor movements that underlie that sensation. In this regard, even the most basic musical listening experience comprises elements that pertain to human activity and agency by nature. As the outcome suggests, participating in musical activities, especially in a collaborative and imaginative environment, can nurture empathy and create social bonds [12].

This discovery, as a result, shows how IMT is capable of improving social communication skills in ASD children by having an uplifting effect on their MNS. Making music together with others functions as a special atmosphere where people with ASD may dynamically engage and react to the emotional cues in the music with their own expressive motor behaviors. The MNS in these children may be mobilized via this reciprocal interchange, accelerating social cognition and communication abilities [13]. In the end, people may communicate musically in ways that relate to their unique experiences and foster a closer bond and greater compatibility. Beyond the immediate musical experience, IMT also has a lasting effect on the MNS in children with ASD. This approach to treatment can aid responses in routinely social situations by thoroughly honing children’s propensity to pick up on and react to behavioral signals, culminating in strengthened social communication skills [24]. By engaging in physical activities, children with ASD will elevate their ability to maneuver in social situations, decipher nonverbal clues, and cultivate empathy [24].

Venuti et al. [24] launched an empirical investigation to determine the coordinated execution of behavioral and emotive states of movement synchrony in children with ASD and how it brings to focus the efficacy of music-centered therapeutic approaches in promoting communication and self-regulation abilities among autistic children. For this study, comprising 25 children with an ASD diagnosis ages 4 to 6, researchers focused on 20-minute segments from the first, tenth, and twentieth sessions. The findings uncovered escalating synchronous activity throughout IMT, with apparent behavioral and emotional alignment shifts between Sessions 1 and 20. Over time, the children’s physical conduct and emotional states demonstrated an increase in synchronicity with therapists. The children were given the chance to further utilize and enhance their motor skills by proactively engaging in IMT, empowering them to function in rhythm with the therapist. These repetitive and continuous exercises entailing coordinated movements reinforces one's motor abilities and coordination by retraining the MNS [24]. The outcome of the interactive Autism Diagnostic Observation Schedule (ADOS) section in the study likewise pointed out that this rise in synchronization persisted after the treatment cycle had ended. The advancements in emotional and behavioral harmony suggest that children with ASD are able to enhance how well they can match their body language with their clinician during music therapy sessions. This research has considerable impacts, especially since people with ASD frequently find it difficult to communicate socially and nurture their motor abilities. Venuti et al. [24] additionally implies that the gains made possible by IMT could be applicable to other environments and social interactions that do not take place in a therapeutic setting. For children with ASD, this is important as its application allows them to integrate their skill sets to real-world circumstances, improving their motor skills and social interactions in everyday interactions.

In summary, IMT offers an extensive amount of prospective evidence as an intervention that can efficiently stimulate the MNS, bringing about broadened social communication and motor skills. People with ASD exhibit elevated activity in particular neurological regions when observing behaviors, indicating that interpersonal signals have a substantial influence on how the MNS responds [4]. IMT effectively refines the MNS and encourages the progression of motor abilities through the inclusion of numerous sensory methods while incorporating participants in music-making. For such children, the ability to combine auditory, visual, and tactile data facilitates a seamless experience and development [9]. In addition, evidence that IMT has the power to build motor skills and nurture social relationships outside of therapy sessions comes from the beneficial outcomes displayed in children with ASD, such as greater motion synchronization, action observation, and motor simulation [21]. Recent studies appear to indicate that the MNS and areas involved in emotional interpretation, such as the amygdala, have a reinforced link, which supplies children with ASD substantial assistance in accelerating the growth of the MNS [22].

Amygdala

One of the medial temporal lobe's components, the amygdala, is fundamental to grasping the comprehension of how the human brain functions. Linkages to social cognition and maintaining oversight of emotional responses, particularly in the regulation of emotional response and the perception of emotional signals from others during social interactions, constitute its significance [22]. Children with ASD have to face specialized barriers, with symptoms distinguished by barriers to communication and repetitive behaviors [1]. This delivers a compelling field for subsequent research and draws in prospective therapies meant to help with the amygdala's active role in social and emotional functioning in children with ASD. IMT has established itself as an increasingly prevalent therapeutic approach in this sense, showcasing promise in developing emotional sensitivity and empowering social interaction [17].

Children diagnosed with an ASD prevalently fail to discern and react appropriately to social signals [1]. This could translate to elevated stress levels, anxiety, and challenges in establishing social bonds [13]. Consequently, owing to the result of the amygdala's close association with emotions, there is a perceptible increase in activity levels [2]. Recent research by Moore [18] analyzed the manner in which music alters the neural abnormalities within the children. The study reported that passively listening to music or engaging in active music improvisation is capable of reducing amygdala activity. Therefore, the author argues that to include children in musical activities, which motivate emotional expression and social engagement, music therapy professionals can deploy a multitude of tactics and strategies, such as active music improvisation and passive music listening. Children are encouraged to make musical instruments or use their own voices during active music improvisation sessions, acquiring an artistic medium that can aid alongside communication and emotional understanding. In the course of passive music listening sessions, intentionally-selected musical pieces are introduced with the motive of capturing specific psychological and emotional responses and guiding in the regulation of amygdala activity, therefore lowering stress and anxiety levels [14]. According to a study by Lynch et al. [14], leveraging IMT may drastically mitigate the indications of stress in ASD, both psychologically and physically.

The Lynch et al. [14] study additionally points out that IMT may induce endorphin synthesis through lowering amygdala activity, and as a result encourages optimized feelings of joy and a general sense of increased health. Through this, IMT is a resourceful instrument for tackling the issues experienced by children with ASD, who regularly grapple with the upsetting repercussions of sensory overload and intensified responses to stimuli in social contexts [13]. Such ability provides individuals with an enjoyable style of diversion, offering moments of relief from the mounting stresses they undertake and endure [12]. Moore [18] observed that these childrens' stress levels decline through IMT, therefore rendering them more receptive to social interactions and may boost their willingness and ability for social communication. IMT yields a positive feedback loop, as greater social engagement and increased interpersonal communication come about because of diminished degrees of stress, which additionally minimize stress reactions [18]. As a result, this allows children with ASD to enhance their perception in emotional regulation and social communication, given that it is often a challenge for them to establish authentic relationships with others [13]. In the long run, IMT's ability to influence amygdala activity is in line with its primary objective of supporting autistic children in navigating social interactions more skillfully and easily through a collaborative process, while making the process joyful and gratifying for them.

In addition to this, Schaefer [22] obtained information on a specific region of the amygdala, referred to as the superficial amygdala, which displays an elevation in receptivity to changes in facial expressions, sounds reaching the ears, and tunes that appear to be appealing to the individual. The amygdala has connectivity with certain aspects of the limbic and cerebral cortex in order to oversee its expressive and receptive emotional regulation. Using the information revealed in the study, the superficial amygdala serves as a catalyst for emotional regulation brought about by external forces. A handful of the brain regions that analyzes the feelings and the sensations of discomfort or anxiety consist of the mediodorsal thalamus, which is involved with memory and other cognitive tasks; the nucleus accumbens, which mediates motivation and action; and the basolateral amygdala, which receives and processes an extensive range of sensory data [22]. The use of specific songs and musical pieces in IMT to bring about feelings of comfort and joy contrasts with settings where individuals listen to music that may expose them to the experiences of anxiety, uneasiness, or dread. Additionally, the same study states that the hypothalamus, an essential structure tasked with converting our emotions into physical reactions, operates with the amygdala, which interferes with critical physiological processes and behaviors. In addition, the hippocampal formation is essential for cognition, recall, and navigation, significantly influencing the regulation of hormonal corticosteroid release via the hypothalamic-pituitary-adrenal axis (HPA-axis) in charge of controlling the body's response to stress, metabolic processes, immunological responses, and emotional equilibrium [22].

In turn, this process shapes the sympathetic and parasympathetic systems, which, in highly stressful circumstances, prime one's body for "fight or flight" reflexes and, in periods of calm and ease, induce "rest and digest" activities [22]. According to the study, IMT may facilitate a shift toward parasympathetic dominance, which would conclude in more relaxation accompanied by less tension and anxiety. When children with ASD engage musically with therapists or peers, their amygdala learns how to identify and process emotions, subsequently paving the way for a more balanced and controlled emotional state over time. Children with ASD

frequently succumb to challenges in emotional regulation, leading to outbursts, meltdowns, or shutdowns [1]. The functional magnetic resonance imaging (fMRI) and the positron emission tomography (PET) analyses of the Schaefer study [22] supplied information pertaining to how IMT interacts with the amygdala in children with ASD by distinguishing brain responses to pleasant and unpleasant music. IMT, with its emphasis placed on uplifting and harmonious musical experiences, is capable of manipulating amygdala activity in children with ASD, as stated by the trend of how amygdala activity has an inclined increase from its reaction to unpleasant music and fall in reaction to confrontation with pleasant music. IMT advocates positive experiences with emotion and alleviates unpleasant ones by possibly improving emotional reactivity, emotional cognition, and social communication. IMT can better the neural links between social motivation and social ties that centers around these vital reward-related components of the brain. This may result in improvements in social communication skills for children with ASD.

Juslin [11] introduced the Brain Stem Reflex, Rhythmic Entrainment, Evaluative Conditioning, Contagion, Visual Imagery, Episodic Memory, Musical Expectancy, and Aesthetic Judgment (BRECVEMA) theory, which explains how certain basic acoustic elements in music, like sudden loudness or rapid rhythms, trigger a primal brainstem response. Auditory changes and fear-inducing music can evoke heightened emotional reactions by deviating from expectations and creating extended anticipation. Conversely, more pleasant music can generate feelings of joy. Davidson and Irwin [5] demonstrated that the left frontal cortical activity is associated with positive emotions and effective emotion control. In particular, happiness appears to be associated with a certain pattern of brain activity in the left frontal region, specifically in the alpha band (8-13 Hz). IMT has been observed to induce a shift in EEG activity towards the left, suggesting a positive emotional effect from the therapy.

Furthermore, Hausmann et al. [8] found that mood induction by music can alter the brain's typical lateralization bias in emotional processing. In adolescents, listening to upbeat music changed the right frontal asymmetry pattern, often associated with depression and anxiety. This illustrates how music can effectively alter emotional responses and promote emotional well-being in individuals who struggle with emotional regulation, such as those with ASD. Considering the strong connection between emotions and social communication, the influence of IMT on the amygdala in children with ASD can have significant and wide-ranging effects. As emotional control strengthens, children with ASD may experience reduced worry and tension as it gives “direct support to the phenomenological efforts in music-therapeutic approaches for the treatment of disorders such as depression and anxiety because these disorders are partly ascribed to dysfunctions of the amygdala and presumably of the hippocampus,” leading to a more conducive environment for developing social skills [22]. The synthesis of research on music's impact on emotional responses and brain activity underscores its potential as a therapeutic tool. The interaction between music, brain regions such as the frontal cortex and amygdala, and emotional regulation offers a pathway to enhance emotional well-being and social development, particularly for individuals with ASD.

Conclusion

In conclusion, IMT is advantageous as a therapeutic strategy for children diagnosed with ASD. Multiple research has demonstrated that IMT can enhance the activity and

interconnectedness of the mirror neuron system, leading to notable enhancements in social communication and motor skills [12]. IMT effectively facilitates the expression of emotions, resulting in strengthened connections between the amygdala and brain regions responsible for emotional interpretation [22]. Beyond the therapy sessions, IMT can extend its benefits to other structured contexts and social interactions in the daily lives of children with ASD [16]. Ultimately, this pursuit opens up a way for children with ASD to attain improved social communication and an enhanced quality of life.

There are numerous critical study areas that require future research in order to further our understanding of the neurological connections between music therapy and its impact on children with autism. The long-lasting effects of IMT as sustained intervention should be clarified by studies monitoring the development and maintenance of gains in social communication and motor abilities, together with neuroimaging evaluations of MNS activity over longer durations. Furthermore, another research potential is looking further into the link between emotional cues and MNS functioning in people with ASD. It is a fruitful ground for research to examine the precise processes by which IMT modifies the MNS, with a focus on its effects on emotional control and amygdala activity in particular. Research that explains how improved motor skills and social interaction skills developed through IMT may be used in everyday situations can also potentially increase the treatment approach's usefulness in real-world settings. Recognizing the heterogeneity of the disorder, future research may also concentrate on improving and adjusting IMT procedures to specific profiles within the autistic spectrum. By targeting the specific sensory processing differences and emotional requirements of children with ASD, such improved therapies may positively affect outcomes for such children. In essence, a multifaceted research agenda that includes longitudinal studies, in-depth neuroimaging analyses, and individualized therapeutic approaches can further our understanding of the neural mechanisms along with IMT's ability to transform the lives of children with autism spectrum disorder.

References

[1] - American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

[2] - Anderson, A. K. (2007). Feeling emotional: the amygdala links emotional perception and experience. *Social Cognitive and Affective Neuroscience*, *2*(2), 71–72. https://doi.org/10.1093/scan/nsm022

[3] - Centers for Disease Control and Prevention. (2023, April 4). *Data & statistics on autism spectrum disorder*. Centers for Disease Control and Prevention. https://www.cdc.gov/ncbddd/autism/data.html

[4] - Chan, M. M., & Han, Y. M. Y. (2020). Differential mirror neuron system (MNS) activation during action observation with and without social-emotional components in autism: a meta-analysis of neuroimaging studies. *Molecular Autism*, *11*(1). https://doi.org/10.1186/s13229-020-00374-x

[5] - Davidson, R. J., & Irwin, W. (1999). The functional neuroanatomy of emotion and affective style. *Trends in Cognitive Sciences*, *3*(1), 11–21. https://doi.org/10.1016/s1364-6613(98)01265-0

[6] - Gaigg, S. (2012). The Interplay between Emotion and Cognition in Autism Spectrum Disorder: Implications for Developmental Theory. *Frontiers in Integrative Neuroscience*, *6*. https://doi.org/10.3389/fnint.2012.00113

[7] - Grèzes, J., & Decety, J. (2000). Functional anatomy of execution, mental simulation, observation, and verb generation of actions: A meta-analysis. *Human Brain Mapping*, *12*(1), 1–19. https://doi.org/10.1002/1097-0193(200101)12:1

[8] - Hausmann, M., Hodgetts, S., & Eerola, T. (2016). Music-induced changes in functional cerebral asymmetries. *Brain and Cognition*, *104*, 58–71. https://doi.org/10.1016/j.bandc.2016.03.001

[9] - Janzen, T. B., Koshimori, Y., Richard, N. M., & Thaut, M. H. (2022). Rhythm and Music-Based Interventions in Motor Rehabilitation: Current Evidence and Future Perspectives. *Frontiers in Human Neuroscience*, *15*. https://doi.org/10.3389/fnhum.2021.789467

[10] - Johnson, R. E. (1981). E. Thayer Gaston: Leader in scientific thought on music in therapy and education. *Journal of Research in Music Education*, *29*(4), 279–286. https://doi.org/10.2307/3345004

[11] - Juslin P. N. (2013). From everyday emotions to aesthetic emotions: Towards a unified theory of musical emotions. *Physics of Life Reviews*, *10*(3), 235–266. https://doi.org/10.1016/j.plrev.2013.05.008

[12] - Ke, X., Song, W., Yang, M., Li, J., & Liu, W. (2022). Effectiveness of music therapy in children with autism spectrum disorder: A systematic review and meta-analysis. *Frontiers in Psychiatry*, *13*, 905113. https://doi.org/10.3389/fpsyt.2022.905113

[13] - Kim, J., Wigram, T., & Gold, C. (2009). Emotional, motivational and interpersonal responsiveness of children with autism in improvisational music therapy. *Autism*, *13*(4), 389–409. https://doi.org/10.1177/1362361309105660

[14] - Lynch, K. A., Emard, N., Liou, K. T., Popkin, K., Borten, M., Nwodim, O., Atkinson, T. M., & Mao, J. J. (2021). Patient perspectives on active vs. passive music therapy for cancer in the inpatient setting: A qualitative analysis. *Journal of Pain and Symptom Management*, *62*(1), 58–65. https://doi.org/10.1016/j.jpainsymman.2020.11.014

[15] - Mayer-Benarous, H., Benarous, X., Vonthron, F., & Cohen, D. (2021). Music therapy for children with autistic spectrum Disorder and/or other neurodevelopmental Disorders: a Systematic review. *Frontiers in Psychiatry*, *12*. https://doi.org/10.3389/fpsyt.2021.643234

[16] - Molnar-Szakacs, I., Green, V., & Overy, K. (2011). Shared affective motion experience (SAME) and creative, interactive music therapy. In *Oxford University Press eBooks* (pp. 313–331). https://doi.org/10.1093/acprof:oso/9780199568086.003.0020

[17] - Molnar-Szakacs, I., Wang, M. J., Laugeson, E. A., Overy, K., Wu, W., & Piggot, J. (2020). Autism, emotion recognition and the mirror neuron system: the case of music. *McGill Journal of Medicine*. https://doi.org/10.26443/mjm.v12i2.273

[18] - Moore K. S. (2013). A systematic review on the neural effects of music on emotion regulation: implications for music therapy practice. *Journal of Music Therapy*, *50*(3), 198–242. https://doi.org/10.1093/jmt/50.3.198

[19] - *Occupational therapy in home health*. (n.d.). Physiopedia. https://www.physio-pedia.com/Occupational_Therapy_in_Home_Health

[20] - Rajmohan, V., & Mohandas, E. (2007). Mirror neuron system. *Indian Journal of Psychiatry*, *49*(1), 66. https://doi.org/10.4103/0019-5545.31522

[21] - Sale, P., & Franceschini, M. (2012). Action observation and mirror neuron network: a tool for motor stroke rehabilitation. *European Journal of Physical and Rehabilitation Medicine*, *48*(2), 313–318.

[22] - Schaefer, H. (2017). Music-evoked emotions—Current studies. *Frontiers in Neuroscience*, *11*. https://doi.org/10.3389/fnins.2017.00600

[23] - *Spiritune explained: Music therapy vs. talk therapy*. (n.d.). Spiritune. https://www.spiritune.com/post/spiritune-explained-music-therapy-vs-talk-therapy

[24] - Venuti, P., Bentenuto, A., Cainelli, S., Landi, I., Suvini, F., Tancredi, R., Igliozzi, R., & Muratori, F. (2016). A joint behavioral and emotive analysis of synchrony in music therapy of children with autism spectrum disorders. *Health Psychology Report*, *5*(2), 162–172. https://doi.org/10.5114/hpr.2017.63985

[25] - Zauderer, S. (2023). Music Therapy And Autism: Key Benefits. *www.crossrivertherapy.com*. https://www.crossrivertherapy.com/autism/music-therapy#:~:text=Music%20therapy%20for%20autism%20involves,the%20individual%20learn%20to%20speak.