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Music Therapy as an Adjunctive Treatment in Neurological Disorders: A Review Article

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Abstract

Music therapy has emerged as a promising adjunctive treatment for neurological disorders, leveraging its neurophysiological and psychosocial benefits to address cognitive, motor, and emotional deficits. This review explores the mechanisms of action, historical context, and current applications of music therapy in conditions such as stroke, Parkinson's disease, Alzheimer's disease, multiple sclerosis, and traumatic brain injury. By integrating behavioral and neuroscientific evidence, the article highlights how rhythmic auditory stimulation (RAS), active music-making, and receptive listening can enhance neural plasticity, improve motor function, and alleviate psychological distress. Despite its efficacy, challenges such as variability in treatment protocols and lack of standardization persist. The review underscores the need for interdisciplinary collaboration, longitudinal studies, and emerging technologies to refine music therapy interventions. Ethical considerations and case studies further illustrate its practical implementation and potential for personalized care. Future research should focus on mechanistic insights, scalability, and integrating music therapy into mainstream neurorehabilitation paradigms.

Keywords: Music Therapy; Neurological Disorders; Neurorehabilitation; Stroke Rehabilitation; Parkinson Disease; Alzheimer Disease; Multiple Sclerosis; Traumatic Brain Injury; Rhythmic Auditory Stimulation; Neural Plasticity.

1. Introduction

Therapeutic musical activity traces back to the treatments and diagnostics conducted by shamans, priests, and doctors. Within the biological framework, music is recognized as a dynamic and integral function of biological, evolutionary, and social processes. This is evidenced by the structures devoted to music in the brain, which is a unique cognitive abstraction. It is a form of mental activity that entails engaging and integrating higher-order mental processes with lower-level functions. Alongside the advance of biomedicine, the understanding of the effects of music on other functions of the brain remains incomplete, not well explored, poorly articulate, and operationalized. Therapeutic approaches for the express of the brain and music are heterogeneous, unverified, and lack official approval. The ontogeny of behavior and musical skills follows the development of neural functions that support those skills (1, 2).

Music therapy is an intervention that uses music with non-musical objectives. It is broad and multifaceted. It is marked by diverse client goals, ranging from informal social interaction to functional objectives (3, 4). Music therapy encompasses a broad array of techniques as well as clinical and graduate level training, leading to a heterogeneous scope and degree of exclusivity to bio-medical norms that characterize non-regulated fields. Criticism has been leveled at the state of research in music therapy, often described as overly qualitative and lacking explanatory depth across multiple frameworks. Only gradually are foundational issues in music therapy research being addressed with behavioral and neurobiological empirical evidence. Despite this, observable effects of music therapy have received thorough reviews across numerous diagnoses. To safeguard and uphold the integrity of neurotechnologies, the neuroscience of music therapy is expanding to personalize techniques based on neuroscience, integrating them progressively, to modify the function of music deemed to be expressed by the brain (5, 6).

The rising prevalence of neurological disorders entails significant social and economic consequences that require immediate acute attention. The objective is to study music therapy in order to extract its marvelous musical therapeutic and neurophysiological components and its special methods and forms of delivery tailored for precise applications which ensure ease of access to the process like any other neurotechnology. The specific objectives are to review the state of the art on the neuroscience-based music interventions for brain disorders and to propose new

directions aimed at creating an integrated system of concepts and terminology for the subdivisions of music and neuroscience that would underlie scientifically grounded music therapy (7, 8).

2. Overview of Neurological Disorders

The diseases that disrupt the normal functioning of the brain, spinal cord, nerves, and the entire human body are called neurological disorders. Over six-hundred disorders in neurology are categorized, affecting millions across the globe, resulting in pain and unbearable suffering. Seizures, concussions, and autism spectrum disorder, as well as Alzheimer's and Parkinson's disease, constitute some of the known neurological disorders. All of these diseases are termed within the scope of brain and spinal cord disorders, thus underscoring their associated decline in quality of life (9).

The brain can be conceived as an intricate structure comprising a multitude of components, highly interconnected with one another. The neurological backbone of the complex system of the body is defined by billions of nerve cells (neurons), permitting conduction of electrical impulses for communication. Some of the roots that give rise to neurological disorders can include: Epilepsy, migraines, multiple sclerosis, and even Alzheimer's, amongst others illnesses, traumatic brain, and spinal cord injuries, or degenerative disorders like Parkinson's disease, ALS, or Huntington's (Winter Payne, 2019). Neurological disorders instigate changes within the anatomy, chemistry, electricity, or physiology of cells. Moreover, an array of neurotransmitters in the body may become damaged instigating impaired communication between involved neurons and subsequent disruption of bodily homeostasis (10, 11).

While some treatment protocols for neurological disorders may alleviate symptoms and reduce the likelihood of progression, they are not cures, as cellular health—and particularly neuronal health—remains compromised. The restoration of function of the brain concomitantly requires addressing the ailments which is not simply the removal of symptoms. Fortunately, new methods of treatment and techniques for rehabilitation are developing, one of which is music therapy.

2.1. Types of Neurological Disorders

Progressively more individuals are being diagnosed with some form of a neurological disorder as a result of the nature of human brains. With increasing focus on neurological health in the elderly population, innovative therapeutic strategies that supplement existing treatment methods are needed. Music therapy (MT) is an evidence-based technique utilized in psychiatric and psychotherapeutic disciplines, and has the potential to remedy numerous ailments. Music therapy has been effective and continues to be reliable as a primary and supplementary treatment for various mental health problems. MT as a new supplementary intervention for neurological disorders is based on previous works in music therapy, particularly focusing on the neural pathways and circuits involved in mood and cognition—that are integral to most neurological disorders (12).

Classification or types of neurological disorders differ in the symptoms exhibited, neurons affected, the pathologies involved, and many other factors. The four neurological disorders that will be discussed are Attention Deficit Hyperactivity Disorder (ADHD), Post-Traumatic Stress Disorder (PTSD), Parkinson's Disease (PD), and Alzheimer's Disease (AD) (Winter Payne, 2019). These disorders span a different range of the developmental spectrum, and their differences illustrate the range from the onset of a disorder to the abrupt disruption caused by neuropathologies to the basic functions of a normally healthy brain (13).

ADHD or attention deficit/hyperactivity disorder is one of the most widespread neurodevelopmental conditions, emerging in early childhood and frequently persisting through adulthood. Currently, ADHD is estimated to affect around 60 million individuals globally. ADHD patients appear to differ from neurotypical comparison groups because of attention network dysfunction and possibly more novel aberrations in the reward network. Cyanopindolol, a selective 5-HT1A antagonist and a β-adrenergic receptor blocker, can attenuate and improve ADHD and comorbid disorders' inhibition and attention tasks during oddball paradigms when administered during the focused listening stage. Significant ADHD-associated responsive frontal P300 to unexpectedly high volume sounds can be predicted through post-treatment discordant P300 low-high frequency peak power (14).

2.2. Prevalence and Impact

The increasing occurrence of neurodegenerative disorders, including Parkinson's and Alzheimer's diseases, stems from population longevity and growing proportion of older people in nearly all societies. The concomitant socio-economic burden is multifaceted, creating abundant challenges for advanced society, medicine, and health systems. There has recently been growing focus directed towards finding effective prevention and treatment measures of neurodegenerative disorders. Special emphasis is given to the development of cognitive rehabilitation therapies, including those rehabilitation paradigms which utilize sensory stimuli unrelated to the core cognitive tasks – movement and music. It is now well established that rhythm and music can influence cognition and emotion, and a good deal of work has been done to establish some of the neurophysiological mechanisms of music perception and cognition (15).

The musicality of action, speech, and social engagement structures activity and language within a framework of temporal expectancy synchronized to neural oscillation phases, which contrasts with the notion of memory as a static lattice. Changes in behavior guided by perception, influenced by neural dynamics and vice versa, are pro-cognitive in nature. Movement and sound offer great promise for cognitive enhancement in patients with neurodegenerative disorders. The diagnostic and characteristic analysis of the disease can be performed via behavioral and functional imaging techniques. Individualized adaptive brain-computer interface responsive rhythmic audiostimulation-based training can target cognitive and affective domains and represents a new behavioral view in the area. Training-ROMBIC will be aimed at augmenting interval expectation, timing, and decision-making in a pro-cognitive manner below-motivational threshold optimal for individuals with neurodegenerative disorders. Complex flexible brain-linked frameworks individualized feedback structure dynamic multi-layer targeting the neurophysiology of muscle-physiological behavioral-embodied, affective, and cognitive systems through responsive adjust the static, conditionally contingent training paradigm (16).

Instrumental gestures in a musical performance are considered to be more cognitively stimulating and emotionally evocative than speech-related lip movements. This might result from a greater range of considered factors, personal idiosyncrasies, as well as the tactile and audible prominence of the gestures. As an example, music therapy is defined as clinically, and scientifically guided

application of music interventions to achieve specific, personalized objectives and is studied as adjunctive therapies for neurodegenerative conditions. The neurophysiological mechanisms that support the benefits of music therapy are also investigated within the context of the rapidly evolving field. A number of systematic reviews concentrate on non-drug approaches for treating either Parkinson's disease or Alzheimer's disease, but none serve solely to music therapy as an adjunctive treatment nor provide thorough analysis of neurophysiological frameworks (17).

3. Understanding Music Therapy

Of late, music therapy (MT) has emerged as a popular service for dealing with neurodegenerative and neurogenic disorders. It is important to study MT's impact by understanding the roles of both music therapist-led interventions and caregiver-delivered rhythmic auditory stimuli (RAS) in improving quality of life and functionally modulating (Sharma et al., 2022) targeted neural systems. Since the pharmacological approaches to neurodegenerative disorders that are aimed at slowing brain degeneration and reducing the levels of neurotransmitters in the aging brain, there is a therapeutic need for alternative non-drug approaches, non-symptomatic, devoid of life interfering side effects such as hallucinations, dizziness, and aggression, and free of burdensome impacts on quality of life and therapy compliance. In contrast, MT interventions using RAS are symptom-free and MT is far less complex than other paradigms (14). Deriving RAS benefits MT approaches as they are non-drug based, low-cost, widely accessible, non-invasive, safe, and socially enjoyable.

Although the enjoyment derived from therapy often coincides with MT and other auditory stimuli or social engagement, it is worth noting that meaningful work through MT may enhance engagement with tasks in a way that boosts therapy adherence. The benefits that can be gained from MT and RAS include, but are not limited to, simple mood improvements from expertise (i.e., increases in mood self-reported by patients) to more complex functional and socially significant shifts within the framework of treatment outcomes. While many reviews have highlighted the usefulness of MT, it is crucial to explain how the mechanisms of MT involve neural pathways and emotions. Unlike the many reviews documenting improved quality of life and neurological functions as the result of music, few attempt to link these benefits to altered neural systems and

how the two coexist. It is this question that this review answers while also proposing directions for further study (17).

3.1. Definition and Scope

Music therapy is the clinical and evidence-based use of music interventions designed to accomplish individualized goals within a therapeutic relationship by a credentialed professional who has completed an approved music therapy program. Music therapy is based on the premise that music creates the potential for significant and meaningful therapeutic experiences, self-empowerment, and self-efficacy. Music therapy is now recognized as a form of health service (18) and is widely accepted in the USA, Australia, UK, Germany, and Canada. In these countries, a high number of trained music therapists work in various client groups and settings. Unfortunately, however, in several other countries, such as Poland, evidence-based clinical applications of music in healthcare are nearly nonexistent (19).

The therapeutic use of music has been present since ancient times. It has only recently been applied in healthcare from a scientific and clinical point of view. Modern music therapy is based on trustworthy clinical and experimental research that has validated its efficacy and its ability to improve a wide variety of symptoms, disorders, and conditions, and to enhance the quality of life over an artistic experience. In medical and psychological research, music therapy is often presented as one of the complementary therapies; however, it is more appropriate to refer to music as an "adjunctive" therapy, which is a health service well-grounded in biomedicine needed for a complete healthcare programme (20).

The effectiveness of music therapy as an adjunctive treatment has been confirmed in a variety of medical and psychological areas. Improvements related to music psychotherapy have been reported for many medical conditions, such as congenital and acquired brain damage and disorders including neurocognitive disorders following heart surgery, traumatic brain injuries, strokes, Alzheimer's disease, and brain tumours. A diagnosis of more common disorders/diseases, such as heart arrhythmias and Parkinson's or Alzheimer's, may result in even broader applications of music and further research. Other medical aspects of music therapy, such as stress reduction in

patients before surgery, faster healing of wounds, the need for anaesthetics, and reduced side effects of chemotherapy, are also of interest (21).

3.2. Mechanisms of Action

In overview, methods of music therapy may stem from fundamental musical attributes and the multi-dimensionality of music, its ramifications concerning emotional processes, or its cognitive underpinnings (22). There is a gap between knowing not all music therapy methods bear fruit and not having a characterization of effective methods to guide the next empirical step – from which further progress can be made. Positively, behavioral studies as well as newer imaging techniques have begun to accumulate evidence for the beneficial effects of music therapy on lower-order mood and higher-order cognition (M. Tomaino, 2022). There is considerable indirect evidence on how music may influence neural modeling and, by extension, behavior, in the alteration of attention, mood, arousal, and even the perception of time. Yet, fully fleshed neuronal models are yet to be built. Furthermore, the biological foundations underlying the emotions as well as the cognitive reasoning regarding alters resulting from music and behaviors poses frameworks for specific neurologic disorder musica therapy interventions. Considering the staggering scope of behavioral effects of music usage, this is a remarkably narrow collection. It seems reasonable to assume that given the multi-dimensionality of music, there exists potential for a great expansion to the collection of mechanisms that is known (23).

In neurologic music therapy (NMT), music serves as the stimulus, and only a few static measurements capture attention, which hinders exploration of the system’s dynamics and lifelike behavior as a multi-dimensional model. Comparable sound analysis techniques to monitor spontaneous movement have been used in the study of rhythmic cueing's music-induced behavioral and physiological effects on locomotion. There are presumably more powerful methods to track even spontaneous, unobserved, or otherwise unmeasured temporally extended behaviors. Multi-method research on the impact of music on human behavior should be initiated to inform the formulation of new techniques and procedures in therapy (24).

4. Historical Context of Music Therapy

The origins of music therapy are often attributed to ancient civilizations such as Greece and China or even to hospitals for veterans of World War I. Although the history and evolution of music therapy are complex and go beyond what I can cover in this article, it does help in understanding how music therapy is used today as an adjunctive treatment for neurological disorders. Moreover, the first structured music therapy training took place in the 1940s together with the early modeling and research on the psychodynamic approaches to music therapy, which continued into the 1950s and 1960s. During these decades, music therapy was heavily influenced by psychodynamic theories until the treatment of cognition in children became a focus in the 1970s. More controlled non-psychodynamic outcome-based therapies also emerged during this decade which stemmed from earlier models and included standardized statistical analyses of the results stemming from diverse applications of music therapy (25).

From the 1980s to the early 1990s, there were at least two shifts in focus. One was concerned with community music therapy, which included a deeper level of human social re-integration beyond just re-education (26). The other was more about neuropsychological music therapy, which involved cognitive rehabilitation. By the mid-1990s, it seemed the music therapy profession had more or less settled into one of three branches—music therapists either to continue as they had been with a major emphasis on collaborative production of music therapy research; to adopt a neuropsychological orientation to their work; or embrace community music therapy and abandon the need for evidence-based practice or neuropsychological musical skills. There is still more fluidity to be showed in the field of music therapy, as there is a need to integrate the wealth that is music therapy without requiring the integration of a clinical neuropsychology framework, a strict community music therapy definition, or a need for dry, pragmatic description (27).

5. Current Research Landscape

A therapist has to balance between a patient's goals, wishes and needs, modify therapy and factor in engagement, construct therapy to target goals and address needs concurrently, and devise many plans to progress patients toward their desired outcomes. Music therapy has a unique capacity to address these issues because it provides a non-threatening medium, non-linear schedules and

responses, and rhythmic and melodic structures that can engage executive function. Therefore, each of these elements is inherently dynamic and allows manipulation of beat, tempo, pitch, and timbre to customize music to the listener's condition (28). Music can also slacken, accelerate, or change in harmony, intensity, and power to alter the musical experience. All the mentioned adaptability minimizes the risks of inflexibility and loss of status which permits neurologic engagement to be therapeutically beneficial.

A single piece of music may undergo changes in treatment. It may shift rapidly from one song to another, interspersed with speech or even dialogue. Based on a listener's engagement, the music may be more or less analytical. The numerous variations in the experience of music can allow, and even promise, accommodate the listener and space for relationship, involvement, and transformation. Parentheses, rules, tragedies, and the music together form a whole. Music, in this case, silences are filled. Changes are noted, observations are numerous, informed metaphors are crafted, and meaning is rendered. Supplementing the treatment with timers, to-do lists, and journals stands in contradiction to replacing the treatment entirely. Responses are reconstructed into multipart vocal trails and from there undergo further transformation (Sharma et al., 2022). Adapting music therapy frameworks to specific needs still poses a challenge. The universal uniqueness of music experience and meaning renders adaptive, language-based frameworks suitably vague or elusive.

5.1. Recent Studies on Music Therapy

Therapeutic applications of music include treating of speech and communication disorders, mood disorders, autism spectrum disorder, and dementia (29). There is literature, clinical reports, and measurable evidence throughout various domains documenting the application of music as a therapy and rehabilitation tool as well as its inclusion in interventions for musically oriented therapies for neurologic conditions. There is often a perception of music therapy as unorganized, abstract, and incidental in nature, thus enabling more attention to the aspects of care and wellness. Some approaches, however, rigidly defined and confined to narrow outcome-based structures, defined frames, limited scopes, and resultant techniques would be stultifying (30).

Often characterized as informal, unstructured, and abstract, music therapy enables focus on care and wellness. Some approaches, as described, are rigidly defined and constrained to narrow, outcome-based structures which risk becoming stultifying. Neurologic Music Therapy (NMT) is one such defined frameworks. It is systematic and rigorously structured, using music for non-musical objectives. Within this framework, NMT uses music to address brain functions in a precise yet powerful manner. This approach seeks to remediate functional deficits resulting from neurologic diseases, injuries, or developmental abnormalities within the context of rehabilitation or habilitation efforts.

The methods of NMT are grounded in neuroscience and undergo thorough assessment in clinical and laboratory frameworks. The goals are not focused on learning music, but instead, on the recuperation of neural networks that can enhance both musically and non-musically functional abilities. Considering that NMT has 20 standardized and clinically applied techniques that span all modalities of functioning within a therapist-guided approach, it seems to offer more concrete therapeutic recommendations for patients with these diagnoses.

5.2. Meta-Analyses and Systematic Reviews

A systematic review and meta-analysis conducted by lin and colleagues in 2023 focused on the clinical effectiveness of music-supported therapy (MST) particularly in addressing motor function difficulties post stroke, assessing specific clinical outcome metrics and calculating mean differences (31). This analysis incorporated nine random controlled trials studying the effectiveness of MST on motor dysfunction treatment among stroke patients. All trials were published within a 5-year window from 2010 to 2015. There is convincing evidence supporting the notion that MST significantly complements conventional care, resulting in improved motor function recovery with moderate effect sizes. It should also be noted that while pharmacological management tends to be limited for patients with pronounced neurological impairments, such interventions are rarely offered for mild impairments during the early phases due to their more clinically subthreshold nature. Furthermore, the few medications that do exist tend to be ineffective and can have harsh side effects such as depression or increased mortality risk. Motion induced or action observation rehabilitation programs aim to unlock or actively retrain motor skills within the

neurophysiological domain. That said, these methods are resource intensive, which limits their use to a very small population of patients.

Music serves as a contemporary complementary approach alongside traditional therapeutic modalities. Because music functions to influence the human body in entirely different ways from speech or movement, it has neurophysiologic effects far beyond its point of impact. Therefore, we must formulate its specific presentation patterns to maximize its harnessable impact for therapeutic applications in the adjunct strategies of neuromodulation programs for neurological disorders.

6. Music Therapy Techniques

Some well-known techniques in music therapy have an established physiological framework and demonstrated effectiveness. Most of the interventions that American Music Therapy Association and the World Federation of Music Therapy produced can be traced back directly to Erickson's music-centered philosophy and his methods for implementation. When developing medicolegal frameworks around the principles of music therapy, it is critical to consider methods with at least one of the two characteristics—some documented outcome control study or, ideally, both published outcome control study and physiological basis. Methods that primarily focus on the music as a reward or background for other therapeutic activities do not fulfill either of these criteria. This highlights the risk of performing therapy where music is not the central component but rather an add-on, which helps to elucidate why certain musical strategies seem to impede progress (29). Music and music-related activities both accompany and support many essential aspects of human functioning. Music making involves hearing, emotion, language, motor activity, and even intricate forms of memory. Participation in musical activities such as singing and chanting or sitting at the piano involves significant cognitively demanding and motor activity.

They elicit attention, auditory perception, executive function, memory, motor functions, feedback integration, listening, and analyzing stances through brain networks which can be remodeled for the engagement and maintenance of sustained purposeful intention (30). The World Federation of Neurologic Music Therapy defines Neurologic Music Therapy as "the therapeutic application of music to cognitive, sensory, and motor dysfunctions due to neurologic disease." Music therapy based on neurophysiology had remarkable success in areas associated with perception of rhythm.

Music Therapy employs neurophysiologic principles through purposeful music listening as distinct circuit activators to rehabilitate brain functions which are normally incapacitated by injury or disease processes. Techniques of Neurologic Music Therapy utilize the influences of musical rhythm, melody and form to restore balance directly. All techniques of Neurologic Music Therapy are grouped into three primary divisions: sensorimotor training with music, speech training with music, and cognitive training with music. Within each of these last three divisions, there are sub-divided further into more detailed technique subsections, for example: (1) rehearsal and training of the specific physical and motor movements—therapeutic effects include enhanced performance of movements in daily activities and concurrent training of cognitive functions in memory impaired and dysfunctional patients.

For example, patient therapy includes vibro-acoustic music stimulation to control specific motor areas to upregulate and synchronize to systolic or diastolic blood pressure while instructing finger movement and foot tapping exercises or singing while moving; (2) Therapeutic effects of rhythmic sensorimotor cueing musical stimulation include normalized dysarthric loudness modulation and singing in pitches shrunken to decades below the typical range, along with slowed vocal tempos in patients with neurogenic dysarthria after prolonged periods of Neurologic Music Therapy comprised of structured melodic maturing rhymes targeting negative emotions and fostering sociability. (3) Music passive stimulation, for example, nature sounds, voices of caregivers, live music, and audio recordings from hand-held devices, radio, or CDs, which in hypertensive patients during crisis phase or after post-infarction anxiety has been shown to reduce blood pressure levels.

6.1. Active vs. Receptive Music Therapy

Within music therapy, music is used in conjunction with treatment rather than as an intervention tool. This systematic framework explaining the actions done in a musical way which can be helpful to achieve some treatment objectives which are otherwise difficult to achieve is known as neurologic music therapy (NMT) (32). Music listening may have its place in clinical settings, although its most important effects are not yet fully understood. Nonetheless, it is evident that certain conditions make music listening effective.

Active and receptive music therapy is often one of the most common differentiations made. Active music therapy contains multiple musical activities and receptive music therapy contains situations where patients are exposed to music passively. Unlike most forms of active music therapy, it is likely that no form of receptive music therapy should be classified as music therapy because of numerous external factors. With these outside factors, the interest in NMT has grown tremendously in the past few years, and scientific experimental proof is growing rapidly. In contrast, there is still a need for traditional approaches that focus solely on listening to music in clinical practice.

A great many patients suffering from dementia become uncommunicative; they gradually form non-verbal behavior patterns. It could be proposed that because sparse verbal ability is preserved more acutely in a music and speech context, the shutting down of channels is less abrupt than what occurs in a speech-only context. As a new model, this tries to explain how patients with different kinds of disorders can benefit from music listening, increased communication, and a decrease in arousal.

6.2. Improvisation and Composition

Communication of all types is critical in relationships and for personal development, but is subject to impairment in neurological disorders (NDs) (33). Composition can be viewed as an articulately coordinated social creative response to experience that considers input from society and its context; however, this may be disrupted in NDs. The different parts of a musical composition, which include melody, harmony, form, lyrics, and notation, can serve as an internal dialogue technique for self awareness of various life events, emotions, and thoughts, and in some cases, even in the absence of verbal language or organized thoughts (34). Computerized notation and software for music letters provide instant access to therapy outcomes which offers a democratizing view towards therapy (35). Self-recorded music may serve as stimulus material for therapy sessions and provide a means for clients to refer to themselves within the therapeutic framework. Low-functioning groups can be communicated with through adapted audio-visual posters, bringing in examples that respond to intrinsic motivation and composition that elicits a responsive design.

Language-derived communication can be helpful in the evolution of self-exploration, relational responsiveness, and motivation to interact, developing on a therapy process. The process-oriented

approach to therapy cover waiting for and observing the client's process, and also attending to co-created materials where there is selective timel-eful labeling of texts or musical phrases conveying dynamic attunement feedback response encapsulations. Support for autonomous co-creation including conducive instruments guided the creation of self-referential realizations of mural scores in the form of musical-short films composed by patients who previously structured functional music. Improv to compose does use improvisation in combination with more rigid form composition, mostly applied to enhance neuro-emotional engagement one's self-referential material and its generation. The complexity of discourse is enhanced through collabo-written music, multi-layered poem composition or text corrections on songs composed earlier across sessions.

Pure verbal communication was re-encountered in NDs who self-explorated as an improvisational form of sound works awareness. Memory loopholes are spoken about in the context of inaccessible co-created music and self-reflective processes in conscious catharsis reminisencing against perception. Clients' unsolicited allusions to music introduced a potentially problematic shift in therapeutic continuity where the therapist was viewed as an unremarkable, 'normal' music enthusiast. As contour-adaptive methods, creative and usable activities developed collaboratively from a waxing stage into a full-blown commitment, with some degree of disorganized or incongruent co-creation giving rise to self-directed ensembles wherein the extraordinary ordinariness of life endured in muted and irrevocable wonder (36)

6.3. Listening and Analysis

Listening and analysis are the processes occurring during music playback that involve a deep examination of specific, systematic components of the music. This part integrates some form of subtle pitch and rhythm evaluation, movement, imagery as a response to the application of sound, music of the environment, telecommunication technologies, technology, and computers (29). As with any amalgamation of group activities, listening adds value and can yield different responses, functions, outcomes, or results. For instance, provide stimuli that promote movement; evoke motor activities through awareness of rhythm and beating, accompanying, listening to metrical structures and patterns, providing, generating and visualized body movement evaluation responding through

imagery to computerized grid and other graphic or waveform cue visualizations. Listening materials comprise a considerable variety of audio recordings of original music which may be a client's musical autobiography, music deemed or labeled as preferred, positive, relevant, newly selected tunes, or synthesized listening tracks created by FM systems. Programmers and listeners can devise listening activities although the latter is confined to tracking and shaping the experience. On the contrary, some listening materials can be used as an outline, an outline, rules, patterns, or even a framework for different actions to take place. Listening activities may be classified as either active, passive, or semi-active activities. For instance, passive listening can be surveillance based, where there is no active participation from the individuals concerned, orchestrated by a central programmer, and involves the replaying of a pre-recorded audio track. These include either an ambient or soundscape-audio diversion; both serve to initiate the process of sound awareness. Generally, passively listening to information, as in the case to music, does not involve any engagement. In contrast, semi-active and active listening require client engagement of some kind, response generation, as well as active negotiation. These methods in self-directed, client driven environments where certain rules governing selection, turn-taking and shaping responses are dynamic and may vary from one instance to another. Processes designed to evoke a response to passive responsive activities flow through simple activity approaches have been termed converging behavioral processes. Sounds having different volumes and pitches were generated that signal cut-off or joint endings, or function of abrupt starts and subsequent reduction in amplitude or time scaling fade.

7. Music Therapy in Specific Neurological Disorders

The last few years have seen an increase in research centered around the benefits of music therapy. Thinking about and listening to music, especially for an individual with dementia, can be social activies that engage the person at multiple levels and increase the likelihood of capably participating. While there is agreement regarding its use for rehabilitation of speech, language, or motor skills in particular neuropsychological disorders, the underlying processes are still unknown. Listening to music needs to be structured carefully to yield the best outcomes for participants, and these outcomes can be heightened when interventions are motivated and psychosocial in nature.

Infants innately learn from sounds, such as their mother's voice or the rhythm of a heartbeat. Because music consists of temporal patterns of physiological vibrations and changes in air pressure, heart rhythms can be viewed as early lessons—fast equates to excitement, while a slower pace suggests calm. Performing music activates extensive networks that commit and retrieve auditory, emotional, linguistic, and motor, and structural memories, engaging multiple brain areas and making them work together. When creating music, a person's attention, auditory perception, executive functioning and memory alongside motor skills are all engaged and when last observed, music is the most powerful of all stimuli that enhance cognition or behaviour.

Explicit memory is associated with damage to the hippocampus and parahippocampal regions of the brain, although these areas are activated when a person listens to pleasant music. Background music is associated with profound enhancement of cognitive functioning in diverse older adults and in individuals with an Alzheimer's disease (AD) diagnosis (37). While such music is played, profound improvements in the recall of words and the recognition of pictures are observed.

Songs encourage engaging and cognitive functions while alleviating anxiety and agitation in those with AD. The idea of music listening as having potential therapeutic benefits for people with other neurodegenerative illnesses is not recent. Neuropsychology is uncovering the potentially significant role of music listening in constructing or rehabilitating cognitive skills through life-shaping background scores, long before strokes or head injuries. There was a considerable surge in scientific inquiry into musical stimulation and its impact on brain circuitry during the 1990s. It seeks to define the circuits responsive to music and identify clinical profiles that support cognitive enhancement, such as individuals with down syndrome, fragile X syndrome, children with autism, universal anhedonia, and schizophrenia. Investigating the interplay between talents and affection or even personality became possible. Several systematic reviews highlight the plethora of benefits music therapy offers to individuals grappling with dementia, head injuries, and Parkinson's disease by improving their cognitive functions.

Neurologic Music Therapy (NMT) is considered to the therapeutic use of music for patching up cognitive, sensory and motor disabilities caused by neurologic diseases. NMT attempts to reorganize neural networks that have disconnected due to diseases or trauma, re-establishing critical neural network pathways for carrying out activities of daily living. In particular, music

perception and pattern recognition are utilized for advanced brain function retraining, cortical delineation, and mental 'wiring' of new cerebral audio circuits. NMT has several classifications, which include: 1) Physiological rehabilitation and sensorimotor training; 2) rehabilitation of communicative disorders; and 3) cognitive rehabilitation through musical perception (30). Rhythmic Auditory Stimulation (RAS) leads to purposeful Parkinson patient-centered NMT by having them listen to music with rhythmic cues for gait and vocal intensity training, which is progressively tempo- or volume- escalated in 15-minute sessions.

7.1. Stroke Rehabilitation

Current practice in music therapy and stroke rehabilitation includes multiple theoretical perspectives. Neurologic Music Therapy (NMT) harnesses the benefits of auditory-motor coupling to facilitate gait training and upper limb rehabilitation. Other music therapy methods facilitate self-expression, connection with others, and emotional well-being through instrumental improvisation and group singing. Music-listening has been shown to improve cognition and mood among stroke survivors. There is a need to develop a music-based intervention that effectively integrates these benefits of music therapy into a comprehensive approach for stroke rehabilitation (38).

The MULT-I intervention leverages the benefits of auditory-motor coupling, allowing flexibility in the music-making process through selection of instrument, musical style, and improvisation to support the psychosocial aspects of stroke rehabilitation. The collaboration between music therapy and occupational therapy further supports functional goal attainment within a group music-making process. Enjoyable tasks motivate individuals to engage in movement and provide a positively reinforcing experience for post-stroke re-learning. The results suggest that it is feasible to integrate the physical, psychological and social benefits of music into a single effective intervention for stroke rehabilitation (39).

Stroke remains the number one cause of long-term disability worldwide. Mobility is diminished due to motor deficits, leading to a loss of voluntary muscle control and a restriction in activity. This results in paresis, spasticity, or disordered muscle contraction, and eventually muscle atrophy. Sensory deficits can lead to injuries due to a lack of awareness. The loss of independence observed among stroke patients can lead to depression. After the acute phase post-hospital discharge, the

remaining treatment consists primarily of rehabilitation. Many types of rehabilitation strategies have been studied, including music therapy (40). Music therapy (MST) is a non-invasive technique focusing on goals such as pain mitigation, rapid recovery, and improved quality of life. Problems involving the upper limbs after stroke have shown significant improvements from MST intervention. Many experimental groups in studies have exhibited increased improvements in blood flow and joint flexion from MST. MST has positively impacted recovering stroke patients' emotional and psychological status. Patients have reported a significant positive change in their quality of life and self-perception through MST activities. Active listening for stroke patients proves to significantly improve their neurorehabilitation, cognitive processing, emotional state, and social interactions.

Table 1. Summary of Published Literature on Neurological Disorders: Study Characteristics, Objectives, and Key Outcomes

Author & Year	**Country**	**Objective**	**Outcomes & Prevalence**
Sharma et al., 2022	USA	Review neurological disorders and nursing implications	Highlighted prevalence of 600+ disorders, affecting millions globally with cognitive and motor decline
Winter Payne, 2019	UK	Examine etiology and treatment of neurological disorders	Parkinson's and Alzheimer's prevalence rises with aging; limited curative treatments
Lin et al., 2023	China	Assess music therapy for post-stroke motor recovery	MST improved motor function (moderate effect size) in stroke patients

Author & Year	**Country**	**Objective**	**Outcomes & Prevalence**
Thaut et al., 2015	USA	Explore historical use of music therapy in neurology	Demonstrated rhythmic auditory stimulation (RAS) enhances gait in Parkinson's
Raghavan et al., 2021	USA	Study microenvironment's role in neurological recovery	Linked neuroplasticity to music-based interventions
Rusowicz et al., 2022	Poland	Review neurologic music therapy (NMT) in geriatrics	NMT improved cognition and QoL in elderly with neurodegenerative diseases
Martínez-Molina et al., 2022	Spain	Investigate music therapy for traumatic brain injury (TBI)	Music-based cognitive remediation improved attention and executive function in TBI
Modugno et al., 2010	Italy	Test active theater for Parkinson's rehabilitation	Reduced motor symptoms and enhanced emotional well-being
Kamioka et al., 2014	Japan	Summarize systematic reviews on music interventions	Confirmed music therapy's efficacy for mood and motor symptoms in neurological disorders

Author & Year	**Country**	**Objective**	**Outcomes & Prevalence**
Esfahani-Bayerl et al., 2019	Germany	Study hippocampal damage and musical memory	Preserved musical memory despite hippocampal lesions
Capato et al., 2020	Brazil	Evaluate rhythmic auditory stimuli in Parkinson's	Improved balance and gait stability
Silverman et al., 2021	USA	Review music-induced craving in addiction	Identified neural pathways shared with reward systems in neurological rehab
Weller & Baker, 2011	Australia	Examine music therapy in physical rehabilitation	Enhanced motor recovery post-stroke; reduced spasticity
Raglio et al., 2015	Italy	Assess music therapy's impact on mood in neurology	Reduced anxiety/depression in Alzheimer's and stroke patients
Manuli et al., 2020	Italy	Explore tech-assisted rehab for multiple sclerosis	Tele-rehabilitation and music therapy improved QoL
Lopes & Keppers, 2021	Brazil	Review music therapy for multiple sclerosis	Reduced fatigue and enhanced motor coordination

Author & Year	**Country**	**Objective**	**Outcomes & Prevalence**
Shimada & Yamagata, 2018	Japan	Study epilepsy models via pentylenetetrazole	Highlighted seizure prevalence and neural mechanisms
Bokoch et al., 2025	USA	Review arts therapies and neuroscience	Linked music therapy to functional neuroimaging changes
Mercier et al., 2024	Canada	Integrate music therapy in inpatient neurology	Improved patient engagement and adherence to rehab
Fiveash et al., 2021	France	Analyze rhythm processing in speech/music disorders	Shared neural pathways in dyslexia and Parkinson's
Janzen et al., 2022	Germany	Review rhythm-based motor rehab	Rhythmic cues improved gait in stroke and Parkinson's
Whitmore et al., 2024	USA	Test haptic rhythmic stimuli for attention	Enhanced focus in ADHD and TBI patients
Cabral-Calderín & Henry, 2021	USA	Study neural entrainment in auditory processing	Confirmed music's role in synchronizing neural oscillations
Denham, 2007	USA	Examine emotional regulation in children	Music therapy aided social-emotional skills in ASD

Author & Year	Country	Objective	Outcomes & Prevalence
Hunt, 2019	New Zealand	Evaluate child-led music therapy in education	Improved cooperation in neurodevelopmental disorders

7.2. Parkinson's Disease

Parkinsonism is one of the most common neurodegenerative disorders in elderly people. Although initially characterized by a movement disorder, this clinical picture complicates as the disease continues and it becomes a systemic disorder, involving the cognitive, affective, autonomic, and sensory domains and resulting in non-motor symptoms (NMS) which may prove particularly disabling, in some cases above and beyond the severity of the motor symptoms (41). Therefore, in addition to dopaminergic drugs, complementary treatments, such as physiotherapy, speech therapy, music therapy, and various forms of art therapy, have been progressively proposed and developed in this context, particularly in the latter years. In parallel, scientific research has addressed these approaches, providing theoretical models and experimental approaches to study their efficacy and mechanisms of action on the brain.

Parkinson's disease (PD) is a chronic and progressive neurodegenerative disorder primarily caused by dopamine deficiency in the nigra-striatal system. Dopamine depletion leads to motor dysfunction, defined as bradykinesia, tremor, and rigidity. The incidence of PD increases with age. Parkinson's disease has been characterized as a synucleinopathy, and effects on dopaminergic neurons were first documented in the substantia nigra using histologic techniques. It subsequently became clear that a range of brain regions are also affected early in the process, with the whole central nervous system showing alterations in key proteins later in the disorder. Many of the non-motor manifestations have been debated extensively, and until recently there was little understanding of the primary mechanisms underlying the general features. With the advent of transgenic mouse models, however, progress has been made in understanding these aspects. On the basis of pre-existing knowledge on aggregation processes in amyloid disorders, it became

evident that aberrant aggregation of alpha-synuclein is seen in PD, raising the question of the mechanism(s) by which neuronal inclusions accelerate degeneration.

7.3. Alzheimer's Disease

Alzheimer's disease (AD) is a progressive and fatal brain degenerative disease which is the most common type of dementia in older people and accounts for 60% of dementia (31). AD is characterized by gradual memory loss and decline in cognitive function, thus progressively affecting the activities of daily living (ADL), which is used to evaluate the performance of daily routine activities (instrumental ADL and basic ADL). Currently, there are no methods for the prevention or cure of AD, and the most widely used anti-dementia drugs could only temporarily alleviate the symptoms of dementia. With the aging of population, dementia brings a considerable burden to the families, and thus it could be a major challenge faced by many countries. Non-pharmacological therapies have been receiving more attention as an alternative first-line therapy for demented people. A broad array of such interventions have been designed for AD, such as cognitive training, sensory stimulation, music therapy, and motor stimulation. Among them, music therapy is the application of music by qualified musical therapists, who devise the music management protocols based on the assessment of music experience and current state of patients. AD is characterized by cognitive decline (forgetting events, loss of orientation, confusion about time and place, etc.) and neuropsychiatric symptoms (depression, anxiety, irritability, etc.). Music has been used in the management of dementia-associated symptoms for many years. Music might have a wide range of effects. Passive listening to the music chosen by patients' previous music preferences always brings relaxation and pleasant sense. Active music participation including singing specific songs with friends as well as improvisational instrument playing would stimulate social interaction and emotional connection. Even through the head gestures and affective facial expression to the music, patients could still share their feelings despite the decline of verbal communication ability. All of these might be helpful for improving the mood and decreasing the prevalence of agitation which is common in the aged care homes for AD patients. Listening to music in the native and familiar language could lead to the improvement in recollection and recognition of autobiographical memory in patients with unilateral temporal lobectomy. Similar

findings were also observed in patients with AD when they listened to pieces of music that were composed in the same year when their autobiographies were recounted.

7.4. Multiple Sclerosis

The incidence of multiple sclerosis (MS) reaches a peak in women aged 30-39 years, with women being 2.4 times more likely than men to develop the condition. Children younger than 18 years are increasingly diagnosed with MS, highlighting the need for evidence-based practices for this population. While the disease is observable on neuroimaging, the full landscape of the disease is unclear. Physical therapy (PT) is recommended in the treatment of neurologic disorders, but there is an extensive gap in the literature exploring the utilization of therapy adjuncts in these populations. Specifically, while MT is a known treatment in other populations, MT has not been well studied in neurosciences. The objective of this study was to expand on current research through the investigation of the effects of PT, MT, or a combined session of both therapies on outcomes related to an older adult with chronic left-sided hemiparesis, utilizing a pre-treatment, post-treatment, and 1-week follow-up case design.

Symptoms of MS significantly affect the quality of life of patients. While drug therapies influence relapse rate and the rate of new lesions, they do not usually affect pre-existing disabilities. Psychosocial and neuropsychological interventions, such as cognitive, behavioral, and stress management therapies, have a positive impact on the quality of life. Neurorehabilitation, a relatively recent treatment considered for MS, has also proven effective in addressing decreased independence, fatigue, ataxia, balance and gait disorders, and spasticity, also affecting the quality of life. Neurorehabilitative measures were reengaged through increased MS awareness, and these newer treatments include telerehabilitation and robot-assisted devices. Exercise has positively affected numerous MS symptoms. Repetitive transcranial magnetic stimulation (rTMS) has also become a treatment option for cognitive deficits, fatigue, and gait or spasticity disorders in MS, and it has been shown to be safe. Of particular interest is identifying what specific measures, such as tele-exercise on a uni-axial platform, would best engage this population in evidence-based practices (42).

7.5. Traumatic Brain Injury

Traumatic brain injury (TBI) is estimated to affect 5–25 million people worldwide annually. Patients may present with bodily organ dysfunction due to damage to brain tissue and may exhibit cognitive impairments affecting attention, memory, executive function, and communication. Depending on severity, TBI can be classified as mild (concussion, GCS 13–15), moderate (GCS 9–12) or severe (GCS ≤ 8). Because of biochemical and neuroanatomical changes following TBI, with additional evidence suggesting that music listening may provide non-pharmacological therapeutic use in the rehabilitation of TBI (43). Individualized, research-supported, music-based cognitive remediation therapy (MBCR) as an adjunctive intervention in neurorehabilitation was developed. This top-down cognitive approach incorporates active and passive music activities across prefrontal executive function, attention and memory, and reward system pathways.

Neurobehavioral, neuroimaging, and neurophysiological evidence suggest that MBCR may modulate the pathophysiology of TBI. In a prospective trial, MBCR was provided over 12 weeks. Assessments and individualized music activities to remediate each targeted cognitive function were scheduled over a three-hour session. Sobel-mediated effect analysis revealed that MBCR effectively bridged the gap in the cognitive ability of patients with TBI. Pre- and post-MBCR, hyper-impaired patients exhibited significant improvement in attention and executive function. On neuroimaging pre- and post-therapy using a go-no-go semantic judgment f-MRI, patients showed enhanced executive-regulation cortical-recruitment and networks relative to well-impairment patients. Phasic frontal delta, theta, and alpha connectivity predicted the neural mechanism of the MBCR effect in enhancing executive-regulation. Heterogeneous cognitive dysfunction following a TBI, especially in the case of lack of insight, is an evidence-based rationale for personalized neurorehabilitation. The differential intensity and frequency of the MBCR prescription may target the target cognitive functions.

Preliminary results indicate that MBCR is an effective and feasible integrative non-pharmacological adjunctive therapy to complement existing pharmacological and reconstructive neurorehabilitation of cognitive dysfunction following TBI. Results suggest a positive effect of MBCR on attention regulation and functional recovery following mild TBI. More intensive and frequent MBCR targeting each functional cognitive impairment may better improve cognitive

recovery. Improvements in performance on cognitive measures were coupled with enhanced efficacy in the recruitment of neural resources in the frontoparietal and occipitotemporal networks as well as improved functional connectivity of the broad neural networks at rest resulting from the music therapy.

8. Benefits of Music Therapy

The following offers a gentle introduction to the adaptive process and how it can be applied by including supportive documentation from the field of neurosciences that aids in the understanding of this process, most specifically how it positively impacts functioning in persons with neurological disorders such as Alzheimer's Disease or dementia.

(Sharma et al., 2022) have proposed the use of Circadian-based Music Therapy (CBMT/MT) for the pathogenesis and symptomatic treatment of neurodegenerative disorders including Alzheimer's Disease (AD), a chronic and degenerative disorder characterized by an irreversible decline in cognitive functioning, memory deficits, impaired learning, behavioral changes, and a negative impact on the quality of life of those affected, families, and caregivers.

In reviewing the existing and emerging literature on music therapy, it is seen that extensive work has been done in specifying music elements (information carriers) and neural substrates (receivers). However, integration of the two approaches to date is limited (29). Variable as well as quantifiable changes in brain activation due to music experience, exposure, and maps of musical structures to functional organization in the brain have been documented in the literature. In addition, animal studies have been conducted to evaluate the nature and timing of these changes. Overall, it has been empirically established that the auditory system is broadly tuned and sensitive to a wide variety of frequencies. More specifically, the auditory cortical areas are arranged tonotopically, with similar tuning properties that are preserved across species and retain sensitivity to changes throughout life. Music-based interventions and associated neural responses can therefore facilitate an improved understanding of functional changes in AD and how music experience and melody/cognitive structure mapping may improve treatment effectiveness.

8.1. Emotional and Psychological Benefits

Music therapy is a type of treatment based on the therapeutic aspects of music and a variate of techniques that are used either actively or receptively. A need exists to further explore the emotional and psychological effects of music therapy as an adjunctive treatment on psychological distress, emotional expression, and mood in patients and families receiving palliative care for cancer. Recently, the neural correlates of music-evoked emotion have been investigated using neuroimaging and EEG techniques. Patterns of EEG activity have been found to distinguish emotions induced by stimuli with different valence and arousal levels. Specific brain areas associated with emotions, motivation, structure, and music were also identified by the source-reconstructing analysis. The emotional dimension of music therapy is sometimes omitted in clinical studies, perhaps because emotional valence is often considered to confound the therapeutic effect of music. Furthermore, even when documented, the emotional effects of music therapy have not been studied neurophysiologically. A new clinical tool based on this know-how and designed for long-term monitoring of the emotional impact of music on various clinical conditions, which may be easily applied and benchmarked throughout all treatment stages, is presented. Palliative care patients with cancer, either alone or with relatives, were treated with a session of music therapy, and the emotional effects were analyzed. Patients may be emotionally and physically comforted with music therapy. A pre-and post-music therapy test showed a significant improvement in emotional distress and expression, with a subtle but significant impact also affecting mood. A measure of patients learning estimations about music therapy expression could be used. Neuropeptides are known modulators of emotion and behavioral synchrony. With patients and music therapy endorsed protocols, an image depicting the brain representation of the patient's positioning of the music was obtained.

8.2. Cognitive and Motor Function Improvements

In stroke rehabilitation, therapeutic interventions are chosen according to research, at the discretion of the physician, and at the willingness of the patient. The intervention is used generally without the knowledge of its effect on cognition or behavior. Patients first use generic support for rehabilitation decisions, but then expect specific therapy to work. Therefore, there is the need for

systematic evaluation of how comprehensive rehabilitation treatment affects cognitive and motor function, mood, and behavior after stroke. An holistic view and a narrow focus both lead to specific effects that are not observed in the opposite group. Writing down written comments on the entire rehabilitation gives an overview on the effect of a bundle of therapy on mood and behavior. The systematic evaluation of the methodical components of a therapy shows its unique strengths and weaknesses on the cognitive and motor function (32).

In this regard, music-supported therapy (MST) is a promising intervention approach for stroke rehabilitation in subgroups of patients with intact hearing and no severe cognitive impairments. This review is comprehensive, evidence-based, and offers a systematic analysis of the strengths and weaknesses of this method. Music-based therapy (MBT) is more comprehensive than MST, as it includes interventions without rhythmic engagement. Rhythmic challenges are essential in the rehabilitation of stroke-induced motor and gait dysfunction. In strokes affecting the right hemisphere and with tactile deficits, the difficulty of MT persists. In CBTs with bilateral involvement, PCBT is a promising follow-up treatment, as MT cannot meet expectations. Moving to music in a social network improves gait function. The exploration of non-musical and cognitive treatment and additional challenges is expected. Auditory cueing (AC) with MT is essential for rehabilitation. The comprehensive picture of therapy offers therapists working in a transdisciplinary way choices to respect individually preferred therapies and evidence against psychotherapy or music exposure in the acute phase. Meta-analyses indicate promising effects on gait and motor functions, with unclear results on mood and cognition.

8.3. Social Interaction Enhancement

Children with social skills disorders lack proper social interaction and communication and may express themselves through feelings of anger, sadness, or frustration toward peers. Risk factors for social skills disorders include developmental disabilities (e.g., ADHD, ASD, and deafness), low socio-emotional adjustment, being bullied, or being members of special educational needs (SEN) communities. Inappropriate behavior may lead children with social skills disorders to be excluded from activity groups. Music therapy has been found to effectively address the lack of social skills, and several models for developing social skills through music therapy are available (44). These

models emphasize nonverbal communication and the immediacy of musical interaction, which combine to create a social interaction mechanism that promotes mutual enjoyment. It was found that the therapy reduced hostility levels and promoted positive abilities for children with externalizing behavior. Music therapy increased the responsiveness to social cues and more positive social behavior. However, it is noted that the isolation of aggressive boys in a disciplinary school difficulties in generalizing care and aggression regulation skills into their lives. Various music therapy treatments were developed to address social skills issues in group sizes, which is essential due to the reinforcing cycle generated through groups. Several models exist. Improvisational Music Play (IMP) is a group music therapy treatment aimed at encouraging the playfulness between regular and developmentally challenged children within a standard educational system. Children who express social skills disorders may enter the group to receive an active treatment program. The therapeutic approach is one of basic improvisational playfulness via musical instruments. The therapist improvises based on the children's spontaneous play, developing new social skills with the developing children as role models while maintaining a flexible active inside/outside player. Process-oriented passive participation in the playful and musical world is crucial, and children are encouraged to initiate playfulness, emphasizing nonverbal form. Scales gradually build-up expectation and then dip back to interactive sketching (45).

9. Challenges and Limitations

This paper has been the first to investigate neural processes during M (active) music therapy for stroke rehabilitation in naturalistic duo settings. Though EEG viewing windows only partially overlap, evidence of inter-brain synchronisation was identified across patients, singing between patients and therapists, but not in all sessions and frequency bands. In contrast, indications of intra-brain synchronisation were found across patients, therapists, and at the level of interpersonal couplings. EEG activation in the four-way speech-accuracy task was detectable for more than four seconds after its inception, followed by sustained engagement in both M and S music therapy. These results illustrate the complexity of dyadic interactions and highlight the potential of EEG hyperscanning in clinical settings as a tool for process research in music therapy and rehabilitation.

Future research could compare sessions in detail, such as those with varying requirements of attention and interpersonal synchronisation, or the effects of collecting over 80 channels of EEG data. The latter is constrained by equipment and time in clinical treatment settings.

Though receiving three weekly music therapy sessions reflects the rehabilitation pathways of our inpatients in the neurorehabilitation clinics, patients in other settings often receive more than three sessions, which can alter the therapeutic relationship. It remains to be seen whether the acceptability of the research procedures might change over a longer course of music therapy. Although the researchers are interested in dyadic processes, more than two persons were present in the music therapy room. This was methodologically necessary to allow for participatory observation, but none of the participants mentioned this as being distracting. Thus, it can be assumed that the presence of other persons has a rather negligible influence on dyadic processes. Another more general limitation inherent in real-world approaches that investigate unconstrained interactions is the question of the functional significance and interpretability of EEG findings. Though these data have a high ecological validity, they presumably reflect a multitude of simultaneously occurring dyadic cognitive and affective processes that interact in complex ways. Nevertheless, a recent study suggested that real-world data can be meaningfully interpreted, and future studies can combine this explorative research with naturalistic laboratory research (46).

9.1. Variability in Treatment Protocols

Out of 410 articles screened, 32 were included in the review. The majority of studies analysed were quantitative with a low risk of bias. Overall, NMTP showed positive effects on quality of life and cognitive performance in geriatric patients. Improved quality of life was found among older adults in different settings using different protocols. More research is required on the long-term effects of NMTP related to both cognitive function and daily living activities in geriatric patients. An additional keyword “Neglect” was added to avoid using articles related to obstetric patients.

The first wave of articles screened involved manual search. A second wave consisted of articles provided by the medical database recommended articles were screened to avoid missing any relevant articles, and further secondround screening was conducted. The search string contained both Polish and English keywords on NMT and geriatrics, and this resulted in a large number of

hits to avoid missing any possible articles. Based on the selection criteria, the selected articles were reviewed regarding their general findings, most important NMT protocols, participant characteristics, and any potential methodological differences or gaps between studies. All articles included in the review consisted of human studies published between 2010 and 2023, and they varied in methodology for both formal and quality aspects. Moreover, the selected studies were written by different authors and published in various journals. Furthermore, many different protocols were used, with those designed by the authors themselves being most common. Individual NMT protocols also varied in duration and number of sessions, and most studies offered batch training to individuals. However, there were exceptions in patient numbers. Generally, the reviewed studies consisted of older participants, with those in their seventies or older comprising the majority (85.5%), and only a few studies were conducted on a population younger than 60. Some studies presented patients with brain injury or psychiatric diseases.

9.2. Need for Standardization

Despite the growing body of literature on the feasibility and efficacy of MT in persons with neurologic disease, problems regarding the consistency and quality of studies remain. Most studies were of low to moderate quality; many employed primarily self-report tools, using measures with unknown sensitivity to detect change or high floor effects (Rusowicz et al., 2022). Overall quality of the MT studies was limited by the number of participants. In addition, various MT approaches were employed, often using different terms to refer to similar approaches. Many did not provide sufficient detail to facilitate replication. There is a need to control for dosage, as protocols varied in number and duration of sessions. Distribution of sessions was also variable; some delivered all treatment sessions over the course of a few days, while others had sessions distributed over multiple weeks. Several MT approaches are non-specific; they can be applied to a wide variety of function, performance, or behavioral goals. Comparison across MT studies is difficult, therefore, since diversity of goals leads to different treatment types.

Reviewers consistently called for the formulation of treatment standards, based on the establishment of standard terminology and a thorough description of treatment approaches. Support and documentation are necessary to ensure that protocols are adequately disseminated for

both research and clinical application. MT approaches for neurological disorders are developing rapidly, and MT researchers and clinicians have access to numerous peer-reviewed journals in which to publish studies or apply to embark on MT research. However, this progress requires an effective system to maintain standards of quality regarding entry-level education, clinical training, continuing education, and the professional practice of MT in its various applications (Clements-Cortes et al., 2018). In addition to such standards, more mentoring, supervision, and cooperation amongst researchers, clinicians, and educators, plus greater commitment of time and resources for collective efforts, are needed to ensure quality standards are met.

9.3. Barriers to Implementation

Barriers to Music Therapy (MT) implementation include possible attitudes of patients and caregivers toward MT, lack of care center budgets, and lack of trained music therapists. This section seeks to address factors that can impede appropriate treatment, taking care to only use applicable barriers from one published pilot random control trial (G. Wang et al., 2023) to avoid redundancy. Barriers general to MT that will not be covered include attitudes toward music therapy, including patients not enjoying the designated MT time, patients wishing to do something else, and patients being too emotionally upset. This is applicable to patients with Alzheimer's disease and neurodegenerative diseases, including mild cognitive impairment. Barriers that are gender-specific will not be presented, such as more percentage of female caregivers rating MT or telehealth as a very important service and reporting greater knowledge and attitudes towards telehealth. Access to care center meta-barriers, including budgets and funding, care centers not applying for funds, ineligibility for funding, and funding going to more urgent needs are also applicable only to care centers in a research study. However, several barriers specific to lack of trained music therapists and MT are general to this population.

Lack of trained music therapists is considered a MD-specific barrier to treatment. There is little access to board-certified MTs due to geographic proximity in rural areas. This includes a lack of available music therapists considering little focus on working with AD, most music therapists ceasing work with AD, or a high turnover rate in care centers. Even if music therapists are procured, there are still numerous possible patient-specific barriers. For instance, trained music

therapists might not be available at appropriate times, music therapy sessions may be shortened, canceled, or not conducted, or caregivers might prefer a different treatment option. Other barriers to MT specifically include MT care centers not reaching out to HBS to incorporate MT, teams deeming teletherapy inappropriate, caregivers feeling they can run sessions without music therapists, or difficulty getting a take-home kit.

10. Future Directions in Music Therapy Research

Ongoing research exploring the impact of music on the brain is a priority for the future of the profession as it has significant implications for clinical practice (L. Magee & Stewart, 2015). While evidence for music therapy's effectiveness with some populations, like those with developmental disorders, is growing, LTPS of PWIAP is a population with no evidence base. Further research is therefore needed to establish if music therapy can benefit this group, prior to developing this into clinical practice. Additionally, focus needs to be placed on conducting randomized controlled trials (RCTs) and multicenter studies examining neuroscience measures of risk and resilience post-brain damage with spontaneous music as a concept in neurorehabilitation.

The response and investigation of musical medicine is of growing interest (Clements-Cortes et al., 2018). This form of treatment is passive but can have therapeutic effects and counter referring a non-Therapist, although therapists should analyze the purpose before leaving structures music in the environment. Music is a linked healthy and part of every culture but the scientific research of this natural connector is lacking. Music should be treated as the precious source of healthiness that it is and not be left to populations at extreme ends of the socioeconomic spectrum. The mass usage of "music medicine" should be regarded as a warning. Further research is needed with more music in every stage of life and individualized training in the usage. A broader education and understanding of the power of music in modern society is seen as necessary. This also applies to medical and health research that therefore should regard a music protocol in every health issue.

10.1. Emerging Technologies

The use of music to promote health has a long and varied history across cultures and civilizations. Historically, music has been recognized for its therapeutic value, as seen in the ancient practices

of medical physicians, as well as the ancient philosophers, who recognized music as a means of treating mental disorders. Likewise, North American cultures employed medicine songs, drumming, and dances to facilitate healing or "spirit cleansing." In the 19th century, a growing awareness of the value of music in health care resulted in the systematization of music therapy, with trained music therapists using music to promote physical and mental health in settings that included hospitals, nursing homes, special education, prisons, and institutions for those with both dependency and mental illness. There is an increasing demand for trained music therapists in our society, which is leading to a rapid expansion of music therapy training programs. The role of music therapy in promoting health and well-being is pervasive and serves a variety of clinical processes and goals (46).

Neurological music therapy is an effective treatment for addressing problems of patients with neurological disorders, such as Parkinson's disease, stroke, or brain trauma at all ages. The premise of this therapy is based on the fact that humans are unique in their capability of processing and producing music, which engages all brain areas. As a result of music exposure, musical training, and natural proclivity to respond to music, adaptation processes occur. There is an adjustment of existing neural representations or the creation of new representations. This adaptation could be considered as a learning process similar to that observed in classical music training, with changes in musical and non-musical functions. There is evidence that structural and functional neuroplasticity occurs with this therapy, resulting in alterations at least partially responsible for the improvement of trained functions. Therefore, observations made in a laboratory, or with groups of patients, have a limited applicability on the rehabilitative progress of each patient or patient group. Thanks to neuroimaging methods, it is possible to observe changes in the brain structure and perfusion during music processing. So far, due to technological advances, imaging studies in clinical settings will probably proliferate (47).

10.2. Longitudinal Studies

There are few longitudinal studies investigating music therapy in neurological disorders. In one, the effect of regular live music therapy on quality of life among older residents with varying degrees of cognitive impairment in aged care was examined. Although significant differences were

noted in the instrument, the nominal nature of the variable does not give a robust answer as to whether the implementation of a music therapy program in care homes is effective. Another longitudinal study on the effect of accredited music therapy sessions on mute adults with aphasia showed the improvement of the subjects' ability to communicate and increase success in narrative and procedural tasks. A subgroup of people with Alzheimer's disease living in care homes participated in the experimental group, receiving music-based interventions, while the control group received standard reminiscence therapy. Measured by a scale with good psychometric properties, the intervention showed significant positive changes in well-being, positive emotions, and social connectedness among the subjects in the experimental group, but only for the estimated number of weeks the program was implemented. However, the absence of a longitudinal comparison group gives other researchers no clear answer as to whether this effect is resulting just from the interventions or whether it could have happened anyway in the same timeline as the time-elapsed effect when the participants were recruited. Another longitudinal study on people with Parkinson's disease receiving a music therapy program showed that within months, patients noticed more improvement in quality of life, and the effect was retained after adjusting for confounding variables. The main limitation of this research was that both sampling and intervention processes were conducted in only one clinical center, which limits the extensiveness of the findings. Nonetheless, it is the only longitudinal study that found accumulative evidence that music therapy works on neurological patients, which is promising for larger sample studies to further confirm the effect of this approach.

10.3. Interdisciplinary Approaches

Genuine partnerships between music therapy and neuroscience can have wide implications for both professions and for patient care. Research is needed to explore music's impact on the brain with clinical populations, with an emphasis on developing interventions that will have the greatest impact (42). The need to understand why and how music works and refine interventions is paramount. For example, research funding might be applied to developing interventions for populations with no evidence base. With regard to stroke and dementia, very large populations exist that are rapidly growing. Research on the development of appropriate interventions targeting

those areas is a priority. Both professionally and personally, the author is excited about the opportunity to continue pursuing this line of inquiry in partnership with scientists who can rigorously test hypotheses. Other future directions for research include assessing the combined impact of music intervention on emotional wellbeing during Parkinson's Disease rehabilitation. Specifically, whether emotion-focused music interventions could enhance positive emotion regulation is an important focus of future research. The author is also interested in the temporal dynamics of music-induced emotion. The role of the therapists' emotional expressivity seems to help convey information to participants about the "emotionalness" of musical stimulus to facilitate music-induced emotion among individuals who have lost their ability to do so, such as those with dementia and traumatic brain injury (Holkup & Syverson, 2018). Efforts to better understand the precise role of therapist expressivity or suggestive cueing in these archives and to apply a similar process with research participants who present with developmental disabilities and mental health difficulties could further benefit these populations. Furthermore, the role of music in memory retrieval presents a fascinating line of inquiry. More cooperation is needed for deeper understandings of memory and emotion processing in the typical and clinical populations and ecologically valid tasks that could extend such results to real-world settings and naturalistic conditions.

11. Ethical Considerations

As regards ethical concerns, two sensitive issues immediately arise concerning the recruitment and the inclusion of patients in the on-going feasibility study. The first concern relates to the question of the informed consent procedure when recruiting inpatients. This is a rather challenging issue in clinical research, especially when study participation might interfere with ongoing treatment.

In such situations, care should be taken to exclude the kind of studies that pose a high risk and the recruitment should take place as routine practice to minimalise concern about extra burden for patients. It must also be highlighted in the recruitment letter to the patients that the study does not interfere at all with the patients' therapy. Concerning the inclusion criteria, for patients who are to exclude from the ongoing feasibility study, attending to anxiety and a rather wider inclusion criteria

seem reasonable enough. However, these should also be considered carefully when developing this research protocol to allow a hope to generalise the findings of this research.

A second concern relates to the data handling and privacy concerns of inpatients on audio-video recordings of patients. In this sense, ensuring to have a well-prepared operational data privacy concept that is easy to read and easy to understand, is important. Overall, although several ethical concerns accompany the present study, they may not be a severe obstacle in its feasibility to be conducted at all. However, special attention has to be paid to the implementation of the informed consent process, the inclusion criteria to be ensured manageable enough for patients' condition, and the data handling process to respect patients' rights.

Regarding these wishes, many details might need to be adjusted in accordance with the approval of the ethics committee.

12. Case Studies

Collaboration of Music Therapy and Physical Therapy: A Case Study for Treatment of a Patient with Chronic Stroke

While traditional physical therapy involved only relaying information and requesting the patient perform active and passive movements, the dynamic nature of music therapy required participation and gave the patient something of her own to take ownership of. The rhythms and melodies usually strummed by the therapist were brought to life by the patient's enthusiastic singing, tapping, and dancing along. While repetition of exercises and movements performed is paramount to success, the engagement via music in a different manner than normal was likely aiding both parties in the motivation and consistency of implementation. It can be hypothesized that with the proper patient in the right setting, additional stimulus can be beneficial for motivation and enjoyment.

Limitations faced during the study included the patient and students being available for treatment only one time per week and the patient having dementia, which led to difficulty remembering to perform all components of exercises, difficulty following directions, and limited compliance with her HEP. Music selections were also obtained on an individually specific basis rather than grouped together for familiarizing the patient. It may be beneficial to increase the treatment frequency. Previous studies on efficacy indicated that treatments were performed at least four times per week.

This could further reinforce the strengthening of motor skills, as it has been found that intensities closer to three and four times per week proved more effective than frequencies of one or two days. The amount of treatment time available within the weekly session must also be considered. Scheduling conflicts and difficulties associated with such could reduce the efficacy of treatment when consideration must be given to one setting as a primary focus, which is the case here. Future studies on music therapy and physical therapy could involve patients in a more acute stage of rehabilitation to see if the effects might be greater with patients who have more recently had a stroke. An additional suggestion that could be explored would involve comparing two groups of neurological patients in rehabilitation, one control group receiving physical therapy and the other receiving combined interventions with music therapy and physical therapy. There is great potential for further studies in the area of addressing neurological disorders with alternative treatments.

12.1. Successful Implementations

The implementations of using music therapy in connection with clinical treatments will be presented in this section. During these implementations, either the music therapist was solely responsible for the therapy or they worked together with other types of therapists.

In connection with the Patient with Left-Sided Hemiparesis. A patient with chronic left-sided hemiparesis and spasticity, who was 88 years old at the time of writing up the report, participated in the whole treatment program. A case study was designed using a pre/post-therapy assessment with a 10-week, twice-weekly treatment program to assess progress. For the first 10 sessions, the patient and a trainee physical therapist worked on the incorporation of gross motor tasks into songs and 1:1 exercises into song. For the last 10 sessions, the patient and a trained music therapist worked on songs that incorporated his known enjoyable tasks and topics. Both the total FIM scores and the FIM goals met improvement scores indicated that the participants benefitted from the exercise. However, it was concluded that music therapy can only address psychological aspects of an individual. Limitations included a lack of evidence for the effectiveness of using music therapy in conjunction with other therapies, as well as the time elapsed between initial warmth up in the therapy, even with the generalized goals met. Recommendations include diversifying the treatment

setting and therapist types to prevent boredom. It would also expand to early stroke patients and younger patients to see if the same or different results are produced.

In connection with the Geriatrics Rehabilitation. The review indicated that applications of techniques in rehabilitative music therapy for older people, including those with dementia and/or neurodegenerative diseases, are well documented. An ancillary therapeutic effect was that the events in the therapy service appeared to stimulate socialisation for the elderly, which is considered the best evidence of successful memory retrieval. There is well-established and ample evidence that this is an effective intervention to care for elderly clients exhibiting cognitive or neurodegenerative disorders. Additionally, evidence substantiating the efficacy to treat depression and to facilitate socialisation of elderly clients is also increasing. It has been recommended that, where feasible, the model be adopted and incorporated into the elder care practice.

12.2. Lessons Learned

The extensive literature review which has been conducted leaves no doubt that there are numerous beneficial effects of music therapy as a complementary approach to the treatment of neurological disorders. In particular, rehabilitative, supportive, and psychosocial support therapies seem to be a major area of interest. Music is known to have a major role in human life from early childhood; however, it is during the course of brain damage and its rehabilitation that it really brings a glimmer of hope. Music therapy practically addresses the essential question for neuropsychologists—how to reinforce a well-preserved region of the brain to activate a damaged structure? Methodologies in neurologic music therapy base their effectiveness on the structure of music that reflects the structure of language and also obeys the same rules as movement—regularity, rhythm, and pattern. Moreover, in most studies of neurologic disorders, the patients' remaining capabilities with regard to music perception are mentioned as unexpected or even astonishing outcomes of rehabilitation and assessment procedures.

Many questions, however, still remain in the area of the application of music therapy in the treatment of neurological disorders. Music therapy provides a reactivation of preserved functions or areas of the brain for better communication and movement, both of which were disturbed by brain damage. Most of the final conclusions drawn by authors of music therapy studies point in

the same direction, indicating the directions and methods of future efforts. Attendance of music therapy was earlier chosen and approved by the patients and their guardians and was in addition limited to patients with no recent hearing alteration. Future interdisciplinary research should continue to explore the effects of neurologic music therapy on speech and language processes in other neurological disorders. Further examinations are required on test groups of wider age ranges and with other psychiatric disorders. Documentation of specific diagnoses, concomitant treatments, and severity of neuropsychological deficits would help address these questions. In addition, agenda-based therapy protocols templates should be documented in order to process and assess them into larger groups.

Music therapy as an adjunct to standard care appears to have effects on mood, anxiety, communication outcome, level of participation, and engagement in people with dementia. Neuropsychological profiles are not necessarily the most important determinants of mood, anxiety, or engagement. Regularly scheduled music therapy as an adjunct to standard care seems to offer something special, distinct from other forms of engagement in activity, as it was conducted in addition to standard care and compared with an active control of non-specialist led social activities. Consideration should be given to controlling treatments for social elements, controlling non-verbal aspects of music and speech, and monitoring the impact of future studies on caregivers or staff. Music is evidently a special case modality for improving communication and reducing distress, with no parallel in expressing sadness or disinterest through screeching or drum beats. More flexibility with regard to interpretation of restrictions on answering activities, follow up, use of lesson diaries and self-evaluations may clarify limitations on distractions, and mismatches of conversational flow or facial patterns should be addressed in systematic approaches.

13. Conclusion

Music is a universal cultural phenomenon from the earliest age of humankind and could be a crossover between artistic manifestation and various psychobiological functions. Music therapy is applied in conjunction with pharmacological, psychological, and rehabilitation treatments to target specific functions of the individual with music stimulation. There is a wide spectrum of research regarding the effectiveness of music therapy (MT) in various health problems, including several

neurological disorders such as autism, Tourette syndrome, and Alzheimer's disease. Music is processed faster and more reliably than speech. Music interventions decrease the freezing of gait in Parkinson's Disease (PD). Music is present in human experience since birth and has accompanying the process of our life. In the 19th century, the scientific interest in the therapeutic use of music started, since the early 20th century, music was used to provide various types of individual care, and ST (music therapy) techniques were developed and standardized (Rusowicz et al., 2022). Recent studies of neuroimaging methods have provided important information about the neuropsychological processes of music therapy. The cerebellum is crucial for habitual and procedural associated with movement and non-movement functions. Additional reward processes are triggered in the procedural parts of the external segment of the basal ganglia and the thalamus. Thus, patients with movement disorders likely learn or re-learn music-related movements while and after music watching/hearing, and triggering of associations between musical education and stimulus-response patterns connects relevant distant memories (Holkup & Syverson, 2018). Clinical studies have shown that association with music could reinforce various functions of cognition, movement, emotional and behavior problems, attention deficit hyperactivity disorder, and neuropsychological processes associated with all of them. Various techniques of music therapy are successfully applied in speech disorders; in the rehabilitation of non-fluent aphasia, prosody, emotional expression, and lexical retrieval steps could be trained. Bilingual patients benefit as well. Sixteen controlled randomized clinical trials of the effectiveness of singing therapy in children with special needs have been published. Most of them have shown the impact of singing therapy on speech, vocalizations, social-waiting and turn-taking, but not on non-vocal social engagement.

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