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Music Therapy and Music-Based Interventions in Neurology

Perspectives on Research and Practice

Humana Press

Current Clinical Neurology

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To all the people who have invited me into their lives during the most intimate moments of theirs. Bearing witness to and being one small part of your stories is the ultimate gift, and I carry them with me always.
—Kerry Devlin

To my dear family members (강기창, 함현숙, 강원석) for their unwavering love and support. Your presence in my life has been a constant source of strength and encouragement, and I am truly blessed to have you by my side. Also, I extend my sincere appreciation to my exceptional work team members, Alex and Kerry, for your outstanding contributions and collaboration. Working alongside you has been a pleasure, and I am grateful for your support, which has enriched our team's dynamics and achievements.
—Kyurim Kang

To my mother Susanna, for inspiring me to become a neurologist and helping me with my first Music Medicine experiment in fourth grade. To my wife Brooke, without whose unwavering and loving support this effort would not have been possible.
—Alexander Pantelyat

Preface

Music Therapy and Music-Based Interventions in Neurology: Perspectives on Research and Practice is intended for music therapy students, practicing music therapists and other clinicians (including, but not limited to neurologists, psychiatrists, psychotherapists, rehabilitation specialists, and nurses) who care for patients with neurological diagnoses. The chapters succinctly cover the key uses of music-based interventions (MBI) for specific neurological diagnoses and associated symptoms. They are written by nearly 40 authors from four continents who have contrasting (yet in our view complementary) expertise. This is intended to encourage the reader to consider multiple approaches in their clinical and research work on MBI. Clinical case vignettes are included throughout to illustrate the various music therapy and music medicine applications in neurology as reviewed in each chapter. Because so much remains to be learned about the mechanisms behind MBI in neurology, future directions for research and clinical work are discussed throughout the book. Whenever possible, key concepts and summary points are combined in tables and figures for the reader's convenience. The editors have endeavored to provide a consistent structural framework for each chapter while maintaining the authors' individual voices. All editors have contributed equally.

Baltimore, MD, USA — Kerry Devlin
Baltimore, MD, USA — Kyurim Kang
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We acknowledge the invaluable contribution of our co-authors in creating this book. It would not have been possible to cover the broad range of Music Therapy and Music Medicine approaches for neurological diagnoses without the complementary expertise of many clinicians, researchers, and educators who contributed to the book's chapters. We are enormously grateful to the patients and families whose collective experience is described in the book's many case vignettes. These vignettes serve as a consistent reminder to the reader of the ultimate purpose of the book: to help improve the quality of care and quality of life for those affected by neurological diagnoses.

Contents

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1 Introduction: Principles and Overview of Music Therapy and Music-Based Interventions

Kerry Devlin, Kyurim Kang, and Alexander Pantelyat

Introduction

While melody and rhythm perception are not unique to humans [1], music is a profoundly human activity. It can uplift us during life's most difficult moments, immerse us in the here and now, inspire us to excel at work or exercise, and drive us to cooperate with others. Traditionally, the study of music has been grouped with the Humanities, but recent decades have seen the flowering of Music Neuroscience. This has been bolstered by the advent of study tools such as functional magnetic resonance imaging and positron emission tomography, which have enabled a better understanding of how our brain perceives music in all its forms [2]. In turn, there has been a burgeoning of research and clinical activity utilizing melody and rhythm to enhance health—in particular, neurological health and wellbeing. In line with increasing public attention to the potential health benefits of music, the National Institutes of Health recently established the Sound Health initiative and its associated funding program, and the music therapy field has been gaining increasing recognition.

This book is intended for those interested in music therapy specifically and the use of music and rhythm generally to improve the lives of those with neurological diagnoses. These are often associated with serious physical and mental health challenges, adversely impact quality of life, and profoundly affect a person's sense of self. Throughout, we aim to embrace a multifaceted approach to this topic and acknowledge the limits (and even potential harms) of reductionism and the traditional medical model when designing music-based interventions (MBI). We also emphasize the need for collaboration between the persons delivering a MBI and

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those experiencing it. Notably, the recently published NIH Music-Based Intervention Toolkit [3] acknowledges the fact that *the traditional behavioral/experimental medicine framework is one of several legitimate conceptual frameworks that can be used in MBI research that could merit NIH funding.* Additional conceptual frameworks described in the article include, but are not limited to, a Music Therapy framework (utilizing a combination of psychodynamic, humanistic, behavioral, and music-centered approaches to serve individual needs); a Neuromechanistic framework (conceptual grounding of interventional studies for humans in basic neuroscience research); and a Resilience framework (a context-based support model wherein "therapeutic music environments possess structural elements that support autonomy, encourage the freedom of expression, and promote interaction of patients with their environment") [3]. The authors note that framework choice should be guided by the target patient community, research stage, study design (including specific intervention type, comparison group and outcome measures), and the specific research question.

Who We Are

As an editorial team, we share a collective 30 years of clinical experience working at the intersections of music therapy and music medicine in neurology. We work as a team at the Johns Hopkins Center for Music and Medicine in Baltimore, Maryland, where we are positioned in various roles—senior music therapist and music therapy supervisor (Kerry), postdoctoral research fellow and neurologic music therapist (Kyu), and center director, clinician-scientist and movement disorders neurologist (Alex). We each work with patients with neurological diagnoses and their care partners in outpatient and inpatient contexts and are committed to furthering recognition of the benefits of music therapy and music medicine on both local and global scales.

Book Overview

Our contributing chapter authors are thoughtfully selected experts from different continents (the Americas, Europe, Asia and Australia) and hold different perspectives/worldviews that are sometimes in tension. This was fully intentional: we would like to illustrate the myriad ways MBI can be framed and implemented to benefit those living with neurological diagnoses.

Each chapter includes the self-locations of the authors to help the reader understand the perspective these authors bring to the topic. Relevant terms and concepts are defined and a narrative literature review summarizes the current state of knowledge about research and clinical applications of music therapy and MBI for particular neurological diagnoses. This is supplemented by clinical and community-oriented case vignettes describing relevant applications of the approaches discussed in the

chapter. The chapters are rounded out with a conclusions and future considerations section.

Music therapy and music medicine are distinct yet interconnected disciplines that harness the transformative power of music to support physical, emotional, and cognitive well-being. Both music therapy and music medicine make use of MBI. They share a common foundation in recognizing the transformative potential of music (Fig. 1.1), but in our view distinguishing between these enables practitioners, researchers, and patients/clients to make informed decisions, develop targeted interventions, and achieve wide-ranging outcomes in diverse clinical and non-clinical settings.

We use the term "music-based interventions" in this book as a way to refer broadly to the use of music and rhythm to improve human health. Music therapy involves delivery of MBI and/or other therapeutic modalities to individuals or groups by a certified professional with a degree in Music Therapy (minimum Bachelor's degree in the United States, often Master's degree, and at times PhD), with the goal of establishing a therapeutic relationship and supporting well-being in partnership with a patient's larger care team. Music medicine refers to the use of MBI by anyone (including patients themselves) who is not a certified music therapist. Below, we briefly summarize the content of each subsequent book chapter.

We begin by delving into what is known and unknown about the mechanisms of MBI and music therapy as pertains to neurological diagnoses. In Chap. 2, Fujioka and Hunt focus on four areas of inquiry: (1) motor rehabilitation; (2) interpersonal synchrony; (3) pain management; and (4) affect regulation. Activity-dependent neuroplasticity, motor learning, auditory-motor coupling, and basal-ganglia-thalamocortical loop activation are described as key mechanisms relevant to motor neurorehabilitation. The authors also denote four processes underlying interpersonal synchrony: auditory-motor coupling for rhythmic entrainment, empathy processing for understanding others, dopaminergic pathways connecting prediction

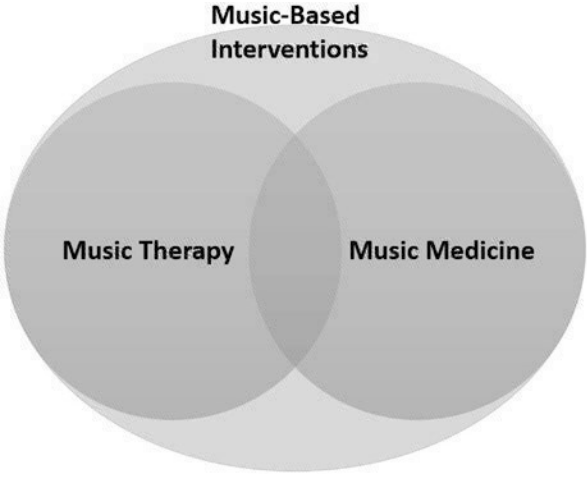

Fig. 1.1 The relationship between music-based interventions, music therapy, and music medicine

and reward and oxytocin's role in social bonding and stress reduction. With respect to acute and chronic pain processing, the authors explain the concept of the neuromatrix and delineate the contributions of the autonomic nervous system (ANS), limbic system, and descending pain modulatory system, Similarly, they describe the roles of the ANS, limbic system and the hypothalamic-pituitary-adrenal axis in affect regulation. In each of these areas, the authors give examples of MBI approaches utilized to date that engage the above mechanisms.

In Chap. 3, Kim, Palumbo and Raghavan summarize the use of music in stroke recovery and rehabilitation. They position the role of MBI, Neurologic Music Therapy (NMT®), and music therapy in the multi-disciplinary context of neurorehabilitation. The impact of music listening on mood, memory and language in those with stroke is linked with structural and functional changes on brain imaging. Rhythmic auditory stimulation and techniques that involve playing musical instruments (including Therapeutic Instrumental Music Performance, Music Supported Therapy and Music Upper Limb Therapy–Integrated) are linked to recovery of motor function. In describing approaches to language recovery following stroke, Melodic Intonation Therapy and group choral singing are highlighted, with the latter approach potentially improving social isolation and enhancing mood. Examples of technology-assisted approaches, such as MusicGlove and musical sonification are provided.

In Chap. 4, Tamplin, Bower and Siponkoski address the use of music for traumatic brain injury (TBI) and disorders of consciousness (DoC). They position MBI as ideal tools for acute TBI recovery because music stimuli can be readily adapted to different levels of arousal and engagement among patients. The authors provide guidelines for delivery of MBI for TBI and DoC, focusing on regulation emotion and arousal, rehabilitation of motor and cognitive function and monitoring and adjusting the MBI over time to support ongoing recovery. The authors conclude by emphasizing that future studies should assess imaging and biofluid markers of TBI and consciousness recovery to delineate the neuroanatomical and neurophysiological correlates of behavioral changes in response to MBI.

The use of MBI for movement disorders is described by Koshimori, Kang, Devlin and Pantelyat in Chap. 5. The authors outline the application of rhythm-based approaches including rhythmic auditory stimulation (RAS®) and other NMT® techniques such as patterned sensory enhancement (PSE®) and therapeutic instrumental music performance (TIMP®) for gait and upper extremity function, with a focus on Parkinson disease. A discussion of integrative music therapy approaches includes experience-oriented and context- or ecologically-oriented music therapy, which are differentiated from, but may be complementary to, functional outcome-oriented paradigms like NMT® [4]. The authors emphasize that a holistic approach to music therapy in movement disorders is more likely to meet the various (and often changing) needs of a patient over time. The authors suggest that future studies should investigate movement disorders such as chorea, dystonia, tics and atypical parkinsonism.

In Chap. 6, Lee, Wilson and Howland provide an overview of MBI for neurological diagnoses affecting speech and language. They describe the connections between language, melody and rhythm processing, discuss the OPERA hypothesis (with an

emphasis on brain network overlap for music and language processing) and place this in context of MBI use for developmental language disorders. The authors describe melodic intonation therapy and several NMT® techniques used for speech and language rehabilitation. They conclude with a call for bidirectional collaboration between music therapists, neuroscientists and linguistics experts to improve evidence quality for MBI in the future.

The use of music for memory disorders, with a focus on Alzheimer disease dementia, is described by Ridder and Tomaino in Chap. 7. The authors define different memory types (including musical memory) and describe their neuroanatomical substrates. They explain how music may act as a trigger for memories in the face of neurodegenerative processes. In their literature review, Ridder and Tomaino draw a distinction between the use of music *as* memory within an NMT® framework to music *in* memory (utilizing an "interpersonal, psychotherapeutic approach").

In Chap. 8, Vinciguerra, Nardone and Holdhoff discuss the use of MBI in oncology, focusing on brain cancer, and propose that in the future MBI can be incorporated as part of glioblastoma management at multiple timepoints (Fig. 1.1 in Chap. 8). They describe the adjunctive role of MBI to support patients undergoing surgery (including awake craniotomy), radiotherapy and chemotherapy for cancer and summarize potential benefits of music therapy for reducing anxiety, depression, and pain and improving cognitive function and communication.

Potvin, Morrow and Pegg discuss the use of MBI in neurological palliative care and hospice care in Chap. 9. They describe how MBI, with emphasis on integrative music therapy approaches and NMT® can adapt to shifting quality of life goals for patients and families in this context and evaluate the impact of MBI on overall quality of life, mood, emotional pain and spiritual distress, motor functioning, and enhanced self-efficacy and inclusion. They also stress the importance of considering the role culture plays in the design and implementation of music in health.

In Chap. 10, Pérez-Martínez, del Cielo Hernández, and Shegogue review the use of music for autoimmune disorders affecting the nervous system. They describe frequently occurring neurological symptoms in autoimmune diseases (Fig. 1.1 in Chap. 10) and discuss the importance of evaluating and addressing the patient's intersectionalities (illness, symptoms, social and medical supports, financial aspects, and the overall identity) when designing individualized music-based approaches. A helpful table describes suggested MBI for autoimmune neurological illness grouped by symptom dimension.

In Chap. 11, Quon, Strýček, Ettinger, Rektor, and Jobst discuss the use of music for adults and children with epilepsy. They discuss several hypotheses regarding how music can impact seizures (including activation of the parasympathetic nervous system via the vagus nerve and impact on dopaminergic and GABAergic transmission) and specifically address the use of Mozart's music for seizure reduction. They also summarize the evidence for reduction of interictal epileptiform discharges with MBI in epilepsy. In their view, future research should investigate the effects of MBI and music therapy on common epilepsy comorbidities, including elevated stress, psychobehavioral and cognitive challenges.

In Chap. 12, Webber and Mamaril describe the use of MBI perioperatively. They write about music therapy and music listening approaches (particularly before and after surgical intervention) and emphasize the role of perioperative care nurses in helping patients select personalized music. The role of MBI in reducing self-reported anxiety, pain levels and improving general well-being as well as vital signs is discussed. This is placed in context of attenuation of sympathetic nervous system activity, upregulation of parasympathetic nervous system activity, and reduction of stress levels in both pediatric and adult perioperative care settings.

In Chap. 13, Clements-Cortés and Mercadal-Brotons address the role of Telehealth in delivering Music Therapy to adults with neurological diagnoses. They begin by noting that telehealth music therapy was not widely practiced prior to the COVID-19 pandemic-imposed changes to healthcare delivery. However, because telehealth affords improved access to services for those who may not otherwise be able to receive them (particularly many individuals with neurological diagnoses), the authors point out that telehealth music therapy is here to stay. The authors discuss key challenges for successful telehealth music therapy implementation, including Internet connectivity limitations, delayed sound latency (especially pertinent for music), ensuring digital security and privacy (with ethical considerations), and financial barriers. They cover telehealth NMT®, Music Medicine approaches (vibroacoustic therapy), and virtual community music experiences. The literature review includes the role of telehealth in supporting persons with dementia and their caregivers, as well as those with Parkinson disease, stroke and traumatic brain injury.

In Chap. 14, Smayda and Harris discuss the use of therapeutic technology for MBI. They point out that digital technology enables continuous data collection (including patient-reported outcomes, ecological momentary assessments, and objective physiological measures) that can ultimately lead to individually tailored music interventions (selection of specific musical features) for those with neurological diagnoses such as stroke, Parkinson disease and multiple sclerosis. Table 1.1 in Chap. 14 provides examples of commercial and academic entities developing therapeutic MBI technologies and the literature review highlights several of them. The authors state that for digital MBI technology to be optimally developed and deployed, "it is critical for all parties to work together: music therapists, academic researchers, product developers, and commercial partners."

In Chap. 15, Davies and Bakan provide an overview of the use of music with autistic people using a perspective informed by the neurodiversity paradigm. This approach aims to work *with* (rather than *on*) autistic people to identify goals and build "strengths, confidence, self-acceptance and coping strategies." The authors (a music therapist and an ethnomusicologist) highlight the differences between music therapy- and ethnomusicology-based approaches to the use of music with autistic people and in part ground them in fundamental differences in professional responsibility (wherein the music therapist is often expected to produce "evidence of change through a therapeutic process" and the ethnomusicologist is not). Behavioral music therapy approaches are critiqued as potentially harmful for autistic people's mental health because they often pathologize autistic behavior and aim to mask

one's autistic identity. In contrast, community-based music therapy approaches such as sensory-friendly concerts and group singing are described as a positive step in the direction of widespread acceptance of the neurodiversity paradigm [5].

In Chap. 16, Rosado and Vaudreuil discuss the psychosocial aspects of music therapy. They describe the use of composition (rapping, songwriting) as a potential way to improve well-being in underserved communities and music therapy's ability to counteract social isolation (so often experienced in those with neurological diagnoses) and foster a sense of belonging to a community of like-minded people. They review the use of receptive music experiences (music-assisted relaxation, music and imagery, active music listening) to address emotional needs of those with neurological diagnoses in both group and individual contexts. The authors call for future studies that consider psychosocial outcomes as the primary goal, rather than a byproduct, of music interventions.

The concluding Chapter by the book's editors Devlin, Kang and Pantelyat aims to sum up key themes and chart a course for future studies and clinical work. We emphasize the importance of embracing a holistic and collaborative approach to develop and deliver personalized MBI to those with neurological diagnoses. We stress the importance of continued mechanistic investigation to improve understanding of MBI's impact on the nervous system and provide a firm basis for subsequent development of interventions that would promote neuroplasticity and improve functional and quality of life outcomes. We also highlight the importance of keeping a patient's preferences front and center when considering therapeutic approaches that involve music. Finally, we express hope that future work will include patients' voices (describing their lived experience with neurological diagnoses) alongside those of researchers and clinicians.

An Invitation as You Read

Whether sharing music with others or resonating with music shared by someone else, music is, by nature, a shared experience. Given this, we invite anyone reading this book to consider the myriad ways the patient themselves can share in the process of choosing and shaping MBI. As an author team, we believe in the importance of shifting the onus away from a deficit-oriented worldview that locates the therapist/music practitioner as sole expert and patient as "recipient" to one that embraces the patient's own agency and ability to make decisions about how music is most relevant to their own medical care and life context—and why.

In this book, we advocate for a non-binary, multi-faceted approached to clinical music therapy and community music practice that acknowledges the fact that different (and at times, conflicting) approaches *do* exist—and that different patients may require exploration of different approaches to have their needs and desires met in ways most meaningful to them. Where possible, we have intentionally invited contributing authors with differing clinical orientations to co-author chapters in this book as an opportunity to reflect the wide-ranging perspectives about MBI that exist across global clinical and cultural contexts, as well as patient communities. We hope

you will find meaning in reflecting on these different ways of conceptualizing the role of MBI in neurology, and that you will consider with us the tension—and possibility—that exist when we acknowledge that there is no such thing as a "right" way to experience music.

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Mechanisms of Music Therapy and Music-Based Interventions

2

Takako Fujioka and Andrea McGraw Hunt

Introduction

A "mechanism" refers to "a system of causally interacting parts and processes that produce one or more effects" [1]. Specifically, in healthcare, we are concerned with "a biological or behavioral process, the pathophysiology of a disease, or the mechanism of action of an intervention" [2]. Importantly, psychological processes and behaviors can be broken down into simpler steps or actions that are differentiated from strategies, coping skills, and goals [3]. Here, we outline what is known about the major mechanisms of music therapy and music-based interventions (MBI), encompassing motor rehabilitation, social and interpersonal synchrony, pain management, and affect regulation. We review evidence from selected neuroimaging, neurophysiological, neuroendocrine and behavioral studies. We describe the foundations for music-based rehabilitation on the basis of auditory-motor connections, sensorimotor feedback integration, cognitive attention and memory processes. We also consider the mechanisms of music's effect on interpersonal synchrony, including the role of auditory-motor entrainment, empathy processing, the dopaminergic system for prediction and reward, and oxytocin for social bonding and stress reduction (Table 2.1).

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Table 2.1 MBI goals and key mechanisms

Goal	Key mechanisms	Music-based intervention approach
Motor rehabilitation	Activity-dependent neuroplasticity, motor learning, auditory-motor coupling, basal-ganglia-thalamocortical loop	Music-supported therapy, rhythmic auditory stimulation (RAS®), melodic intonation therapy (MIT)
Social and interpersonal synchrony	Empathy processing, auditory-motor coupling, dopaminergic reward and prediction processing, oxytocin for social bonding and stress reduction,	Rhythmic entrainment, joint music making, singing
Pain management	Neuromatrix, autonomic nervous system (ANS), limbic system, descending pain modulatory system (DPMS)	Active music making, music assisted relaxation, music listening
Affect regulation	ANS, limbic system, hypothalamic-pituitary-adrenal (HPA) axis	Intentional use of familiar/unfamiliar/preferred music and active vs. receptive delivery

Self-Location/Perspectives

We approach this chapter from different, yet complementary, perspectives. Hunt is a music therapy educator and researcher with clinical experience in inpatient psychiatric/residential addictions treatment and private psychotherapy practice. Her research uses behavior and electroencephalography (EEG) to examine neural responses to music therapy interventions. Fujioka, as a cognitive neuroscientist specializing in human non-invasive neurophysiology assessments (magnetoencephalography (MEG)/EEG)) of music cognition, examines issues of neuroplasticity, auditory and motor processing, timing processing, and joint music actions.

Mechanisms of Music in Motor Rehabilitation

Motor rehabilitation relies on the key principle of activity-dependent neuroplasticity, whereby repeated activation of specific neural pathways (involving synchronized firing of groups of neurons) leads to the strengthening of those pathways, based on Hebbian learning principle "neurons wire together if they fire together" described by neuroscientists Löwel and Singer [4]. This fundamental principle implies that lasting brain changes over time develop in response to musical stimulation. It is relevant to diverse brain injury etiologies such as stroke, traumatic brain injury, Parkinson's disease (PD), multiple sclerosis (MS), and other conditions. The use of music for rehabilitation of specific neurological disorders is addressed in other chapters (Chaps. 3–8 and 10). From the motor-learning perspective, the goal of rehabilitation is to obtain generalized motor functionality for various contexts rather than excelling in a fixed, single-motor task [5]. Neurological operations in musical motor skills for auditory-motor connections, sensorimotor feedback integration, and cognitive attention and memory processes provide foundations for rehabilitative benefits.