# 16 The Sensory Systems, Eurhythmics, and Sensorimotor Music-Based Interventions for Autism and Neurophysiologic Characteristics

**Dorita S. Berger, PhD, MT-BC, LCAT**

## Introduction

Many persons with neurologically, cognitively, or mentally debilitating diagnoses (e.g. Autism, Alzheimer's, PTSD, Stroke, etc.) experience sensory stimuli with such variation that the incoming information can either cause extreme discomfort, be totally undetectable or be so distorted as to be useless. In other words, sensory stimuli entering the auditory, proprioceptive or visual systems may not be detected and coded, or may be detected but then be incorrectly coded (e.g. too loud, to tight, too near, etc.) and therefore may produce inappropriate responses by the brain. This mis-perception and mis-reception of sensory stimuli in the brain causes continual states of distress and fear, thrusting the system into a fight-or-flight response. Such sensory misinterpretation can be overwhelming and at times dangerous. Music is an all-brain, sensory-motor mind/body experience. Treatment that employs eurhythmics, consisting of movement, rhythm, and music's additional five elements (timbre, melody, harmony, dynamics, and form), can address a variety of multisensory issues through carefully targeted interventions addressing physiological and sensorimotor coordination. I will briefly discuss sensory systems, sensory information processing in the brain, and the importance of this knowledge in applying eurhythmics to clinical interventions for regulating sensory systems and achieving *functional* adaptation. I will also present a case study of the alleviation of the sensory distress experienced by a patient with autism and other diagnoses through the application of eurhythmics-based sensorimotor inventions. These types of interventions can calm the hypothalamic-pituitary-adrenal axis, the system that becomes hyperactive when the brain senses fear or danger, ultimately calling for the flow of adrenalin and cortisol in preparation for the fight-or-flight response.

## Background

My first exposure to Dalcroze Eurhythmics was many years ago at Carnegie Mellon University while studying Piano Performance. My course of studies there included two years of Dalcroze Eurhythmics, taught by Marta Sanchez. I knew nothing about eurhythmics, but enjoyed rhythmic movement activities and the systematic approach to rhythmic understanding and internalization. It was fun and interesting and "different," a change from the typical classroom routine. I graduated with a BFA in Piano Performance, continued training briefly at Juilliard Conservatory, performed solo and chamber music, taught private piano, married, raised a family, and my life moved on. I never looked back, nor thought about the elements of my musical background. When my first-born daughter turned three years old we were living in Cleveland where my husband, a former dancer (CMU & Julliard alumni), was teaching at a community college. For my three-year-old daughter, there was no question that I would seek some sort of arts activity. Through friends at the Cleveland Institute of Music and the Cleveland Musical School Settlement, I discovered that Elsa Findlay was conducting Dalcroze classes for pre-K and older children. Ah, eurhythmics. I remember that! So I registered our daughter for Eurhythmics. She loved it, recorder-blowing and all.

Eventually my family and I left Cleveland, moved around a bit, and ultimately landed in New York City again, where I entered the NYU Graduate Program in Music Therapy. I graduated with an MA in Music Therapy, became Board Certified, and obtained a position as the first music therapist at a brand new Connecticut school for neuro-developmentally delayed children, who were mainly on the autism spectrum. Here, as I collaborated with occupational therapists and speech pathologists, I realized that my clinical training was at an infant stage and that I had little knowledge of human physiological function. I began to ask myself some of the following questions: What impact does music have on the function of these children? What is "sensory integration?" What, in heaven's name, is "proprioception?" I had never encountered that word until the occupation therapist spoke it!

So, what was the occupation therapist trying to do in *her* sessions? Above all, why was the occupational therapist coming into *my* sessions to observe what I was doing with the child, saying that what I was doing was having an important impact on their behaviors and sensory responses?

Without being aware of it, or even having purposefully thought along Dalcroze lines, I had been applying eurhythmics activities as clinical sensory interventions with the children! Marta Sanchez's teaching and Dalcroze's principles had unconsciously shaped how I designed treatments to address specific sensory issues – proprioceptive, vestibular, tactile, and especially auditory and auditory/visual processes. After writing three books and several journal articles on music in human adaptation, I obtained my PhD at Roehampton University's Psychology Department, in London, UK. The PhD By Published Work required that I review my published books, articles, theories and case studies and conduct an additional new empirical study based on some of my published theories. As I went about reviewing all my work up to that time, reviewing videos of my clients, etc., I was astounded to discover that almost all of my clinical interventions were sensory, mind/body, and eurhythmics-based! Even after so many years since studying with Marta Sanchez, my eurhythmics training had become so completely a part of me that it was influencing my professional work—from concert pianist to educator to music-based clinician. I had entered the music therapy profession knowing absolutely nothing about the specific application of eurhythmics to interventions for treating specific sensory processing development. As I wrote my dissertation, titled "Physiologic Foundations For Music Therapy: Treatment Model for Autism and Other Diagnoses," I became fully aware that my approach to treatment was, indeed, rooted in Dalcroze Eurhythmics!

I asked myself, "How could I have imagined myself to have been an effective music-based clinician without having first acquired knowledge of human physiological function? What do the brain and sensory systems have to do with music? And why, now, were my (unconsciously adapted) eurhythmics interventions so effective?"

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## The Sensory Systems

When asked to list the senses, most people will cite five senses: hearing, seeing, smelling, touching, and tasting. But in fact, these itemized systems cannot advise the brain of such basic functions as the body's position in space; what the limbs are doing; whether the body is upright, leaning, or prone in relation to gravity; or how the brain knows when the body is hungry, tired, or needing to eliminate waste. Is it the Tower of Pisa that is leaning or the body? If the only way that the brain receives information about internal and external events is through those five senses, how does one know? The two senses that are often omitted, if even mentioned at all, are the proprioceptive and the vestibular systems.

These two, in conjunction with the five others, are critically interrelated sensory systems that provide the brain with information regarding what is happening with the body in relation to its environment. Unless one's brain knows precisely where and in what position the body is, what the limbs are doing, and how to plan functional motor responses, there will not be adequate responses to any circumstance.

The proprioceptive system monitors activities within the body—muscles, organs, and joints—sending information from these areas to the brain. (This is referred to as *interoception*: the monitoring of internal events, position of muscle, joints, organ contractions, etc.) Is the body in sitting position? Are the arms and legs bent, straight, folded, reaching? Is the hand open, closed, fisted, extended? Once the brain receives and perceives the information (hopefully accurately), it will order a response, referred to as a motor plan, so that the body does not fall, so that we do not drop a glass due to inaccurate closure of the hand around the glass, and so forth. The proprioceptive system is in constant review of the condition and circumstances of the body's limbs, joints, and muscles.

The vestibular system, through head positions and inner ear fluids, alerts the brain continuously about whether or not the body is operating correctly against gravity. This requires motor planning in order to assure corrective maneuvers for balance. We all know how our vestibular system falters when we've had too much to drink and that corrective maneuvers are required in order to prevent us from becoming "falling down drunks". The vestibular system coordinates with the proprioceptive system to provide accurate information about the position of the body. Accurate interaction between these two systems is required for the brain to order a motor-plan. One of the most efficient ways to help train the systems of people who have been diagnosed with neurophysiological conditions into developing accurate transmission of information to and from the brain, is through the rhythmic movement exercises of Dalcroze Eurhythmics.

Add to these the tactile and visual systems, and we have four sensory systems working to assure the body's position and well-being in space. The tactile system, monitoring both external and internal events, will alert the brain to environmental temperatures, structures that might be abrasive and injurious to the skin, toothaches, and more. What happens, for example, when one's tactile system alerts the brain about the air temperature in a room? The brain calls for a sweat or shiver response to keep the body within its usual homeostatic settings (i.e. normal body temperature of 98.6). Another simple example is an itch: how does the brain know about it? How does it know where that itch resides? How does it prepare a motor plan resulting in appropriate scratching? This requires astute interaction between the tactile (sensing the itch) and proprioceptive senses, which plan the motor response. Of course most of us take all this for granted, but the brain is very busy receiving billions of bits of electric information transmitted from the sensory systems, many of which require responses. And it must get things right, or problems ensue.

While taste and smell are essential senses for survival, (in fact, the olfactory system is so crucial it even has a brain of its own), one of the single most important sensory systems ensuring survival of the body—and the species—is the auditory system. How one hears, what one hears, from where the sound emanates, how far or near is the sound, and how one discriminates and identifies the sonic information (is it a bomb, a jet, thunder) are immediately crucial to the brain's planning a response for survival. The auditory system is the first system developed in the womb, with tactile close behind.

In sum, there are seven sensory systems including the proprioceptive and vestibular senses. The accuracy of the information derived from all of these systems, the accuracy of the transmission to the brain, and its reception and perception of the information—all this is necessary for the brain to keep the body safe. What does Dalcroze Eurhythmics have to do with sensory processing? To begin with, there is never a moment when the body is not in rhythm and motion, from head to toes, within and outside of the body: heart-beats, releasing of hormones, scratching an itch, neurotransmitters in the brain communicating with one another in rhythms (Buzsaki, 2006), the rhythm and movement of breathing, walking, eating, blinking, even texting one's friends! We engage in rhythmic movement continuously though we are mostly unaware. Adapting Dalcroze Eurhythmics for sensory coordination interventions is the most natural way of addressing the body through its own language and processes.

## Neurophysiological Impairments

One of the main physiological characteristics of autism is a lack of sensory coordination, often referred to as sensory integration deficiencies. Once sensory information is received and processed in the brain as a perception of what is happening 'out there,' the interaction of the bits of information will call for some kind of response: an action or thought leading to a resolution of the information. The behaviors and responses of persons functioning on a "typical" basis—often referred to as *neurotypicals* (NT's)—are considered to be normal reactions to this sensory information. For NT's, once a response has taken place there is a calm *modulation* from that event to another. The modulation is an automatic, functional adaptation to a circumstance, a smooth transition from one event to the next.

This is not the case in persons with various neurophysiological diagnoses, such as autism, various dementias, stress disorders, and depression. Within these diagnoses lie sensory disorganization and sensory non-integration, which result in perpetual, chaotic, fight-or-flight responses (equivalent to fear reactions), because the brain is not receiving or perceiving sensory information accurately. The fear response called for by the *hypothalamic-pituitary-adrenal axis* (HPA axis) releases high levels of adrenocorticotropic hormones that flow rampantly throughout the system in preparation for the fight-or-flight response, as if one were fleeing a tornado! This is the behavior observed in autism: lack of focus, inappropriate motor planning, racing chaotically around a room, heightened ambient hearing and peripheral vision, inability to function in a crowd, inattentiveness to cognitive information, and self-stimulating and involuntary repetitive movements (e.g. hand-flapping, odd sounds, etc.). Sensory disorganization is also very evident in patients with various forms of dementias, post-traumatic stress disorder (PTSD) and other neuro-physiological diagnoses in which chaotic and erratic behaviors are common. Neurotypicals must realize that these seemingly non-functional responses are, in fact, functional for those particular systems.

Music-based treatments for such behaviors as autism have predominantly focused on treating social adeptness, visual focus, attention, language development, and cognitive learning. What is often misunderstood is that unless the sensory systems serve to help the brain call for more orderly responses, no external processes such as socialization or learning will occur, because in a fear cycle the hippocampus shuts down, deferring to the overactive amygdale (the fear organ in the limbic area of the brain) and the rest of the HPA axis. Without addressing this issue, motor planning, if it occurs at all, will be chaotic and disorganized, sound will be received as an excruciating auditory tsunami, vision will not focus, and behaviors will continue to be disorganized. Considering these factors, treatment with music-based interventions can be used to improve systemic sensory organization.

## Dalcroze Eurhythmics and Sensorimotor Interventions

Emile Jaques-Dalcroze, along with others of his time (e.g. Feldenkreis and Laban), instinctively understood that human behavior is about movement and rhythm. Rhythm is everywhere—within our bodies and in the Universe. And of course, movement is an absolute requirement for human function. Moving the body enhances blood flow, breath control, visual and auditory acuity, cognitive attention, and general centering. Movement also prepares the brain to receive information and learn.

With the motor cortex and the auditory cortex in such close proximity, rhythmic music will instinctively instigate movement—usually entraining (synchronizing) with the pulse of the music. One must consider the four aspects of rhythm: pulse, pattern, pace, and perseveration (persistent repetition). That is to say, in addition to pulse, the body understands polyrhythmic patterns within music, the pace with which the rhythms function (fast, slow, etc.), and the repetitiveness of the pulse. Eurhythmics interventions use precisely these aspects of rhythm to address and improve proprioceptive and vestibular motor planning in the brain and body. My research, a pilot project investigating the role of tempo-specific rhythmic interventions for pacing and reorganizing a chaotic system in autism behaviors, indicated a clear and definite positive direction toward focused and paced body responses (Berger, 2012).

Along with extensive attention to proprioceptive and vestibular rehabilitation, accurate auditory function must be considered. Because of the acoustic environment they creates, music interventions play a major role in this area of treatment. The objective of sonic musical interventions is to train the auditory system to attend to specific sounds, to discriminate one sound or timbre from another, and to train for auditory depth perception and auditory figure-ground so that the auditory system is not simply assaulted by a tsunami of sound that the brain cannot process. This is a major reason why persons on the autism or dementia spectrums display fear responses: auditory information that the brain receives is translated as dangerous to the system. It is not usually whether the sound is too loud or too soft, but rather too filled with undecipherable or unpredictable sonic information that cannot be accurately processed and rendered as 'safe.' This is one reason, for instance, that many listeners to very dissonant, seemingly uncoordinated music find the need to squirm, grimace, cover the ears, and want to leave the concert hall. The brain of those with autism spectrum disorder (ASD) has no clue what all that "noise" is, and sets the system in motion for fight-flight! This is also why shopping malls are so frightening to ASD children.

The human being 'hears' with the whole body, not just the ears. While the cochlea and cilia within the ear are the predominant transmitters of action potentials (electric impulses) to the auditory cortex in the brain, the whole body is actually processing sound. Vibrations produced by music are sensed throughout the entire body, although one tends to forget or not notice these sensations. And, if the entire body is a sonic sensing system, music vibrations provide external input, "knocking on the doors" of the proprioceptive and tactile systems. One actually *feels* a sound. Evelyn Glennie, the preeminent percussionist who is profoundly deaf, states that she hears certain pitches in her toes, others on the shins of her legs, others on her shoulders, and so on.[1] Surely we have all felt, across our chests, the massive booms of a bass drum or loud thunder.

Treatment interventions I administer to clients with sensory concerns include attention to auditory processing. Borrowing from Dalcroze, the idea of incorporating auditory (non-verbal) music cues in order to obtain the correct movement response has become a staple in my treatment intervention inventory. I give very few, if any, verbal directives, after initially describing to the client what kinds of responses go with which types of musical cues: turn, sit, stand on toes, move only arms, only legs, and so forth. The development of this astute auditory focus—listening to certain sounds for specific responsive movements—trains the brain to attend to and discriminate between the important sound from the overall background of sounds. This is referred to as development of auditory figure ground (Berger, 2002; Schneck & Berger, 2006).

Adding movement not only strengthens auditory function but also naturally fosters accurate motor planning, because the auditory input from the music continuously calls for specific movement responses. The brain complies, thereby strengthening motor planning, which relies on proprioception and vestibular clues to function. A simple example: if someone suddenly shouts, "Move!!" you do not stop to plan all the variants that need to be in place in order for you to move. You simply move! Eurhythmics activities similarly utilize automatic and instinctive body responses. The Dalcroze concept of quick response activities for internalization of rhythm and imitation (Black & Moore, 2003) is absolutely an essential aspect for treating motor-planning issues. The music does not stop! The beat perseverates—it is on-going! The pace does not wait until one has thought of a plan for movement. The brain and the body just get the job done without further deliberation. This is what I, as a music clinician, look for and rely on: the automatic, intuitive, instinctive and appropriate reaction.

This reaction requires the proprioceptive, tactile, vestibular, auditory, visual (and sometimes even olfactory, as in a sniff of smoke) systems to coordinate automatically for rendering the response. This is what Dalcroze training encompasses, and when adapted to the treatment of diagnosed populations with sensory-coordination issues, it is absolutely indispensable as a mind/body—holistic—sensorimotor intervention.

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## Sample Case

At the time I began working with Michael, he was 8-years old and diagnosed with ASD. Michael had extreme sensory issues and typical ASD deficits. He was unable to tolerate a shopping mall. He was basically language-delayed. He had vocabulary words, could repeat and imitate words but lacked pragmatics (the ability to use words to describe or explain things), or responses to "w" questions. An assessment by his occupational therapist indicated sensory disorganization, noting that he tended to drop things, often faltered with balance, resisted eye contact, and closed his ear to musical sounds. Michael did not like physical contact and thwarted attempts to be held, cuddled, etc. He often seemed not to hear when called. Michael had no social interaction skills.

1 See *http://www.youtube.com/watch?v=IU3V6zNER4g*.

***The human being 'hears' with the whole body, not just the ears.***

Michael's first three 30-minute sessions with me were basically exploratory (for both of us). My studio is set up with various instruments around the room, including drums, xylophones, hanging instruments (gong, triangle, etc.), electric and acoustic pianos, and a central empty space in which to move about. Michael displayed a great curiosity about the instruments—both shapes and sounds—and moved quickly from a clunk on the xylophone to a tap on the drums. Generally, he moved about the room in an unorganized manner, and was not remaining with any one task or instrument for more than 10 seconds, if that! After 10 minutes or so he was basically done exploring and ready to leave. My early interventions included reflecting to him his sound explorations, by imitating what he was doing. Each time he heard my imitation of his sound, he turned to stare at me eye-to-eye.

I have a small trampoline in my studio, which I put out for him to jump upon (with his mother supervising). He would run onto the trampoline, jump once or twice, run off, go about other activities, and then return to bounce once or twice and run off. Each time he was on the trampoline, however, I played the piano inventing a song that described his activity (e.g. "Mike is jumping – 1- 2-3"), to the precise tempo of his jump. At those moments, he would jump while looking to me at the piano! But this, too, was a fleeting event.

The following observations presented themselves during our first several sessions: first, he clearly had a desire to make eye contact, but the motivation for eye contact was the music intervention I provided. Second, he had motor planning and vestibular issues in his upper body, in that when he would pound the drum, it was with his hands, which he preferred to the mallets; something about grasp was missing. Also, in his movement about the room, his movements were extremely rigid, legs spaced apart when he moved, and his movements were mostly in the running mode, with very little body flexibility or dynamics and with very fast-paced body rhythms. Balance-wise, it was obvious that he was not secure, but he was "practicing" corrective movements on the trampoline to avoid falling. Also, his forward navigation included leaning forward as he moved, as if not internalizing the level of the floor (as if he were walking downhill), which was probably caused by inaccurate visual perception. Although he occasionally toe-walked, that seemed to have been already giving way to the more normal heel-toe walking. In general, there was a great deal of anxiety, stress, and fight-flight maneuvers about the room.

Without going into further details here, it was clear to me what goals and sequence of interventions would need to be addressed in order to redirect sensory miscommunication. First, his system was in a continual fight-or-flight mode. Satelliting around the room indicated a 'fear' response to me: escapism, inaccurate perceptions of danger, readiness to flee. So my first interventions would seek to calm and slow his system down, quieting his anxiety through good breathing activities, slow-tempo music, and slow movements. We therefore began each session with sipping water (to center and calm), followed by recorder and kazoo blowing. We continued with deep breathing, slow exhales (creating long tones on the recorder), then making crazy, funny sounds on the kazoo, using the high and low registers of the voice. He sat in his own chair near me when I was at the piano, and I improvised to his recorder and kazoo sounds. From the very beginning of this activity, he sat quietly, never taking his eyes off me! The use of the recorder brought his hands, eyes, tongue, etc. to his mid-line, which promotes awareness of body structure and relationship of the body to the surrounding space. The kazoo influenced vocal tonal expression and functioned as a preliminary to language acquisition and comprehension, though we were, in fact, already communicating with sound (I, too, played the recorder and kazoo, feeding him funky sound ideas as I accompanied with one hand on the piano).

After the opening recorder/kazoo intervention, we moved to the trampoline, with my instructions that he could not step onto the trampoline nor jump until the music said so. The piano would say "step on," "jump," and "step off." He would wait on a small designated plastic square tile, until I played the preparatory chords to which he had to repeat, "… one... two... three..," anticipating the "step on" cue, which was a chord in the upper register.

He had to hold two maracas (fairly large and rather heavy), one in each hand, down at his sides while jumping up and down. As he jumped, I played a song (in his jumping tempo) and invented lyrics which I sang as he jumped (e.g. "jump, jump, jump on the trampoline"). But he was not to stop until the music stopped, that is, until the song stopped. I played eight 4/4 measures, then stopped, which meant "freeze." Then I played a downward glissando to indicate to step off the trampoline, and return to the 'waiting' tile. This activity became a staple for increasing accurate vestibular and proprioceptive information. The intervention expanded into 16 measures, and more, as sessions continued, to secure his vestibular processing and assure that he was attending aurally to the various cues. The purpose of the maracas was to provide further auditory rhythmic feedback to the brain as he jumped. It also reinforced proprioceptive information of the position of his upper body, arms and hands.

Following this, we began floor movement. Moving across and around the room was basically derived from Dalcroze concepts. I began by my asking him if he could do what the music was doing. With tambourine in hand, musical cues told him to march, run, hop, skip, turn around, go down, stand up, freeze, go fast, go slow, show big body-shapes, make small body-shapes, etc.—all while simultaneously playing the tambourine. From the very first time this intervention was introduced, Mike did precisely what the music was indicating, requiring very little verbal prompting. And he so loved this activity, that he would yell "more" each time! His sessions were increased to 45 minutes. There were other times when I would include some scarf movements for upper body motor planning, circling the scarf in figure-eights (like an infinity symbol) in the front, on the side, over head, low down…. first with one hand at a time, then both together. This was done while moving to slow, lyrical music, or marching, and other times while standing still. Hearing loud or soft music ordered his body to move accordingly, thus increasing the flexibility of his motor planning. Also, imitating my movements (sometimes using recorded music, sometimes in silence) served to teach his brain to observe, imitate, and understand body dynamics. We also marched, skipped, etc. to various dynamics: from a soft run on tiptoes, to a pounding elephant-march. These activities also contributed to developing body dynamics.

Drumming activities also involved movement. Hearing this tune or that sound cue would signal him to go to this or that designated drum and play a particular pattern. Other times, a variety of instruments were dispersed around the room with the same intervention approach: hearing high-register trills meant the maraca was to be shaken, a particular low-register chord meant a specific drum, and so forth. Yes, we had moments of simply improvised music making with no particular directives, just playing drums, xylophones, singing, etc. But each activity was still focused on a sensory issue, such as crossing the mid-line of the body, synchronizing parallel arm motions (working toward "thump-thump," bilateral, arm movements rather than the "ka-thump, ka-thump" produced by one arm being behind the other). We also addressed actual music notation comprehension: rhythmic patterns notated on a white board were identified as locomotor movements (quarters – walking; eighths – running; dotted-eighths - skipping, etc.), so that I could write a rhythmic pattern for him to play on a drum. This helped to train his visual sequential tracking and focus. We even spent time at the piano, and he was learning to read tonal notation as well!

## Summary

A central result of my eurhythmics interventions using sensorimotor music-based treatment for this ASD child, was that after about six months of similar and increasingly more complex rhythm and movement interventions, one could observe differences in movement, socialization, bilateral motor-planning, vestibular security, visual attention, motivation to use voice and language, smiling, and definitely movement flexibility and increases in body dynamics. In this particular case, after two years, we progressed to understanding rhythm through notation, eurhythmics, and piano lessons. Mike, now out of High School, is playing piano for pre-school children in the area!

Since I am writing a book that will ultimately detail more eurhythmics-inspired, sensorimotor, music-based treatment, I will not encumber this article with further information. To conclude I will simply state that although Dalcroze and the others were not especially involved in clinical work (though Dalcroze did work with a psychologist and Feldenkreis worked with patients of psychological distress), they were so ahead of time in their thinking that today's sensory-deficient populations are reaping the benefits of their ideas through applications in clinical work.

There is no question that eurhythmics activities, originally designed to help teach rhythm, phrasing, creativity, dynamics, etc. is absolutely functional when adapted in music-based sensorimotor interventions, with goals beyond the internalization of musical concepts. Many clients may not ultimately be able to clap a 3/4 pulse in one hand while clapping a 5/4 pulse in the other—but the brain will be just as challenged to better organize and pace its sensory systems, because in the doing is the process of change and learning.

*Dorita Berger, PhD, MT-BC, LCAT, is adjunct professor at Kean University Music Conservatory, NJ, teaching Introduction to Music Therapy courses. She has 20 years experience as a Sensorimotor Music Therapist specializing in treating autism spectrum and related disorders in children and adults. She has published several internationally lauded books and peer-reviewed journal articles and research on the role of music in human adaptation. Berger received a Fulbright Visiting Professorship to teach Music Therapy in the Ukraine, a Grant to teach and lecture in Argentina and in Italy, and is sought nationally and internationally to lecture and teach about the role of music therapy in sensory processing and behavioral characteristics. Dr. Berger, formerly a concert pianist, conducts a private clinical and teaching practice, consulting services at The Music Therapy Clinic in Norwalk, CT, and workshops on this subject for teachers and music clinicians.*

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