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The Science of Music Rehumanizing Medicine: Scientists and Musicians Discover the Importance of Their Collaboration

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Since the dawn of humanity, music has been perceived as beneficial to health. Numerous are the examples of cultures and populations who throughout the ages used music as therapy. The millenary-old intuition is not lost today. In a recent survey of patients and their families performed at a major medical center, the vast majority of the surveyed responded they believed strongly that music in the hospital enhanced their quality of life (Aboussouan, Jukic, & Chémali, 2009). Despite this overwhelmingly elevated percentage, this quasi unanimity, we should say, the reality on the ground is that music as a therapeutic tool is applied in less than 10% of medical institutions (nonofficial approximation) in the United States, music therapy is just beginning to be reimbursed as a service by Medicare in some states, and the topic of the biological science of music is not taught in any of our medical schools.

In the age of evidence-based medicine, for a discipline to be recognized by the scientific community as a valid therapeutic tool, and in turn by economical entities as reimbursable service, rigorous research and clinical trials are needed. Now, more than ever, research in the field of the neurosciences of music is possible and exciting. The advent of modern technology, such as functional MRI and autonomic testing, allows us to pinpoint precisely the areas of the brain that mediate specific musical functions, determine the variability of heart rate, or measure beat-to-beat blood pressure variations in response to certain types of music or different tempi. We are starting to see more dedicated centers for the study of the effect of music on the brain and the nervous system, and the term *neuromusic* has emerged in the medical literature (Zatorre, Peretz, & Penhune, 2009). Local, national, and international societies for the study of the biology of music are emerging, such as the International Association for Music and Medicine (IAMM), founded in 2009, and attention of the general media to the topic is evidently growing. Now is the time to solidify research, measure outcomes, and show with numbers and hard data the beneficial effects of music on disease.

Aside from turning an intuition that is as old as human existence into a scientific certainty, the benefits of such a demanding endeavor are multiple. Recognition, generalization, applicability, and reimbursement are certainly some of the most important aspects. Advancement of science is another key element. Neurological research using music is an important tool for discovering novel functions of certain brain structures and their interconnectivity. A recent study by Janigro (2009) showed that a predominantly motor structure, the subthalamic nucleus, displays variation in its neuronal firing pattern in response to a certain type of music. The discovery of a sensory function to this basal ganglion implies that it must be connected directly to the auditory cortex or indirectly to music centers through emotional centers of the brain, such as the insular cortex. Another relatively recent study by Bernardi, Porta, and Sleight (2006) showed that the autonomic response to music is mainly related to tempo. Even though the authors did not provide an anatomical explanation of their findings, they certainly opened the door to researching the neuroanatomical pathways that link the ''meter'' centers of the brain, thought to be the cerebellum and the basal ganglia, to the central autonomic centers. The connection between the cerebellum and the autonomic nervous system, even though not quite understood, is strongly suspected. Studies in animals have shown cardiac modulation in cerebellar lesions affecting the vermis in particular (Bradley, Ghelarducci, & Spyer, 1991; Dietrichs, 2008; Goncalves, Rocha, & Silva-Carvalho, 2002). This finding has also been reported in humans. The role of the cerebellum has expanded significantly recently, with the discovery of its role in emotions (Dietrichs, 2008). Extending this thinking, and going back to Janigro's findings, another question that we can raise is whether the changes observed in neuronal firing within the subthalamic nucleus involve the cerebellum, through rhythm perception and the formulation of an emotion.

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It has become clearer that the effect of music on human physiology cannot be explained by a single organ system or a unique medical discipline. A multidisciplinary approach to music research is needed. Centers for the study of music should count among their staff disciplines neurology, neurosurgery, neuropsychology and psychiatry, and cardiac electrophysiology, to name a few, in addition to performers and professional musicians. The study of emotions in music is a perfect example that illustrates the need for such a multidisciplinary approach. Producing an emotion is considered by many as the primary purpose of a musical performance. Many musicians and concert programmers are interested in knowing whether specific composers or particular pieces can create a similar emotion in their audience and whether this emotion could be anticipated and expected to occur at more or less similar moments during a concert. This is an important concern of musicians that should be addressed seriously by the neuroscientific community. It also could have important implications for music therapists. Studying mechanisms of emotions in music is paramount but it does present a multitude of challenges.

One challenge is defining a musical emotion, considered by Panksepp (1995) as one of the main reasons for listening to music. Is it a subjective feeling, a response of bodily arousal, a motor expression, or a mixture of all of these? If we answer the latter, which seems to gather a certain consensus among musicians and scientists alike, we see immediately that studying music-related emotions is already a multidisciplinary task: Subjective feelings necessitate for their analysis a profound knowledge of human psychology, functional neuroanatomy, and neuropsychology. Bodily reactions of arousal involve the autonomic nervous system, the neurohumoral system, the endocrine system, and the cardiovascular system. Motor expression in response to music requires activation of the motor structures in the brain, the brain centers for rhythm perception, and the peripheral nervous system that mediates muscle contraction. In addition to this medical multidisciplinarity, it becomes evident that the musician's input is indispensable: Music cannot be studied as a generic concept, but its varying components need to be assessed individually. The effect of melody, harmony, rhythm, tempo, intensity, timbre, frequency, consonance, and dissonance on the different components of the musical emotion needs to be evaluated as distinct parameters first, before being studied in combination. Furthermore, musical expertise is required in order to dissect a musical composition into its different components or to compose new music according to specific research criteria.

Performing research with live music, which is felt to be superior to prerecorded music in creating a therapeutic response (Holmes, Knights, Dean, Hodkinson, & Hopkins, 2006; Loewy, Hallan, Friedman, & Martinez, 2006), requires the participation of performing artists who subscribe to such research. Last but not least, the effect of music should be researched not only on an audience but also on the performers themselves, studying their emotional response during the process of music production, which, in turn, will likely induce an emotion and result in a physiological modulation of the audience. The active participation and commitment of music professionals is critical to the success of serious research and outcomes in music and medicine. This was made possible through the creation of ''artist-in-residence'' positions at certain major hospitals (Graham-Pole, 2001; Hain, 1998; Lane & Graham-Pole, 1994).

The involvement of artists in medical and scientific research may, perhaps, be perceived by many as an odd combination. This has not always been the case. Arts and science have in the past coexisted in the same individuals who contributed to the advancement of both fields. Mathematicians were often the musicians and the philosophers in antiquity, and it was not uncommon to see such a combination in the Age of Enlightenment. The advent of the technological revolution and the increasing demands of each field in the race to excellence made it more and more rare to see both art and science coexist at a high level in one single individual, moving the two domains further apart. In the era of biophysics, biomechanical engineering, magnetoencephalograms, MRIs, and neurophysiology, we have become more at a distance from the ''ars medicinae.'' But this combination is essential and there is a need for rehumanizing science. Music and medicine and music therapy research are ideal disciplines that reintroduce the humane aspect of art into the rigor of science, reflecting therefore the real nature of the object of this research, the human being, a complex combination of subjectivity and objectivity. While science tends to minimize the importance of subjectivity to the advantage of objectivity, and while we all tend to quantify all that exists, the presence of artists in the scientific world reminds us of two essential facts. The first is that we need each other for the advancement of knowledge. As stated above, music helps science develop. But the reverse is also true. Science helps music achieve its ultimate purpose, which is to create an emotional response in the listener by understanding the different components of this response and proposing favorable conditions that could contribute to its production and reproduction in the concert hall. The second fact that musicians remind us of is that art cannot be all explained by science, particularly musical emotions, in a similar way that faith or love cannot be entirely quantified or explained fully. Their presence within the team helps us, scientists, realize that despite our technology and our best efforts to produce the best science, we have to accept that part of mystery that is inherent to art and may never be explained totally by the most advanced of scientific means. This realization should not discourage us; on the contrary, it pushes us to our limits while helping us to accept them.The ultimate goal of the research effort in music and medicine is to use music as medicine in an effective and reproducible way. This research feeds into the advancement of music therapy (MT). The field of MT was initially built on the intuition that music helps disease and the empirical discovery that it works. Therefore, little was done before 1990 to give the discipline solid evidence-based scientific ground. Things have changed in the past two decades, during which MT has benefited from the technological advancements in fields such as neuroimaging,

autonomic testing, and kinematics and has developed into a scientific paramedical discipline with subspecialties.

A good example of these changes is the development of neurological music therapy (NMT), which has evolved significantly, as Shannon de l'Etoile eloquently reflects. In her article ''Neurologic Music Therapy: A Scientific Paradigm for Clinical Practice,'' she retraces the scientific bases for the development of NMT and gives us specific examples of its applications in gait disorders through rhythmic auditory stimulation (RAS) and in voice, speech, or language disorders through vocal intonation therapy (VIT) or melodic intonation therapy (MIT). The article by Concetta Tomaino illustrates the benefits of MIT through a very illustrative case study whereby the use of this technique yields better results than speech therapy alone. Research conducted at the Cleveland Clinic in both RAS and MIT confirms already the efficacy of these procedures and, as such, concurs with previous studies. Even though a precise understanding of the neuroanatomical pathways and neurophysiological mechanisms underlying these techniques is still lacking, large-scale clinical studies with rigorous protocols will help confirm their efficacy in different neurological disorders. To this day, MT still suffers from the labels *intuitive* or *subjective*. Solidifying clinical research in MT will eventually help the field gain a well-deserved broader and widespread recognition, commensurate with its efficacy. Economically speaking, such recognition will reflect positively on reimbursement rates for MT services, making it, in turn, easier to hire more music therapists in an increasing number of health care facilities and conduct more research.

Unfortunately, music can sometimes have deleterious effects on the organism, when used inappropriately. The stress of repetitive and often misused practice of an instrument is known to cause occasionally injuries in instrumentalists, vocalists, or dancers, severe enough at times to compromise their careers. The treatment of these problems led to the emergence of a novel specialty termed ''performing arts medicine.'' Here again, we and others feel that the best way to tackle the problems of performers is through a multidisciplinary approach (Brandfonbrener & Kjelland, 2002). It is crucial that neurologists; orthopedists; ear, nose, and throat specialists; acousticians; physical and occupational therapists; psychologists; psychiatrists; physiatrists; physicists specializing in kinematics; and others come together with professional performers and musical pedagogues to form one treatment team. Common medical problems of musicians, particularly dystonias, are often multifactorial in origin and benefit most from an interdisciplinary focus. In this special issue, several articles address these problems under different angles. The article by Kristen Thomas and Peter McCann draws our attention to an often underrecognized cause of shoulder pain in musicians: rotator cuff injury. This problem, often misdiagnosed as bursitis and treated with nonsteroidal anti-inflammatory medications with incomplete resolution, cannot be completely resolved unless a comprehensive evaluation by a qualified physician leads to the proper imaging studies and proper treatment, including surgery, if needed, followed by rehabilitation. Knowledge of the instrumental technique and evaluation of posture by a music educator may help the diagnosis and, if done early enough, prevent further injuries from occurring.

The article by Michael Pitman, the Florence Tyson Keynote Speaker at the Louis Armstrong Center's Beth Israel Symposium, stresses the importance of a multidisciplinary approach to treating vocal problems of singers. Musicians need to know the anatomy and physiology of the body organs they use most frequently for performing: muscles, tendons, nerves, joints, spine, and bones for instrumentalists and dancers, and breathing mechanisms and laryngeal anatomy and physiology for singers. The importance of the larynx and pharynx is also approached under a different angle by Michael Benninger. In his enlightening article, the author reveals the importance of this organ and voice, in general, in the evolution of the human species and of music in particular. These examples show us that, as much as the active participation of musicians in the treating team is essential, the participation of health care specialists and scientists in the training of musicians and other performers is as important, leading to a better knowledge of the body and its capacities and limitations and to the prompt recognition of problems should they arise. This, in turn, leads to a prompt seeking of medical attention, which certainly helps with limiting and possibly reversing certain injuries, when recognized and diagnosed early on. It is therefore highly advisable that music schools and music and dance conservatories include medical disciplines in their curriculum and bring on board health care specialists to teach these topics to their students.

It is now clear that problems of musicians and performers are not only physical in nature. Hence, incorporating neurobehavioral techniques into musical curricula aimed at helping music students cope with the high demands of their training and profession may prevent or minimize the likelihood of developing future disorders related to the practice of their art. Louise Montello addresses this essential point by presenting, in a very comprehensive manner, a model of an effective wellness program for music students, integrated into their formal curriculum.

The increased awareness of the importance of the multidisciplinary approach to performing artists' medical problems has led to the creation of ''performance medicine centers,'' where all of the above-mentioned specialists and subspecialists work hand in hand for the betterment of the life of the injured performer. Stephan Quentzel and Joanne Loewy give us a convincing model in their presentation of a unique assessment for musicians. At their Center for Music and Medicine, they emphasize the role of the music psychotherapist in assisting conventional physicians and health care workers to address the problem of the performer, from a biological, psychological, and musical perspective. Today, centers for Performance Medicine can use the advantages of modern communication techniques such as telemedicine, remotely interconnectable musical instruments, and audio and video streaming over the Internet in order to bring together different subspecialists and professional musicians as a single treating team. The members of the team observe simultaneously and in real time the injured performer,

from different parts of the world, and render a common final opinion on the best way to approach his or her problem.

How Do We Move the Field of Music and Medicine Forward?

As in any field of study, research and education are key elements that allow the discipline to grow and advance. I like to use the expression *professionalize the field* to reflect the direction to take. By this, I do not include paramedical professionals like music therapists who already have well-structured curricula at the college level and hold bachelor's, master's, or even doctoral degrees in their disciplines but, rather, the medical profession. The neurobiology of music has gathered enough evidence to support its viability as a stand-alone scientific and therapeutic entity and can now be included in a formal medical school curriculum. The basic science of music and medicine represents a fertile substrate for high-level scientists to work on. Different universities around the world have created or have become affiliated with specialized centers for the study of the mechanisms involved in music perception by the brain and the consequence of this on different body organs. Most of this work has so far been led by neurophysiologists, neuropsychologists, and neurobehaviorists. As much as this can be acceptable at the basic science level, when it comes to clinical or translational research in music and medicine, the involvement of clinicians is crucial. But rare are the physicians who have delved into this field. Physicians, in general, have not been actively involved because of lack of awareness, on one hand, and because the field is perceived as a paramedical discipline, led by music therapists and nurses, on the other hand. Therefore, training new generations of future physicians-scientists in the neuroscience of music and sensitizing them to the clinical benefits of the use of music is the way to assure that the field of neuromusic could become one day a subspecialty of the neurosciences like any other. My hope is that neurologists or other specialists could one day be able to choose neuromusic as a lifetime career path and practice it clinically. This, in turn, will undeniably have positive repercussions on the advancement of the field.

Education in music and medicine should also be addressed to nonmedical professionals, specifically, to musicians. As mentioned above, involving musicians in music and medicine research is fundamental to the success of this endeavor from a developmental standpoint. Another reason for educating musicians to the neuroscience of music is that they can be influential in the spread of awareness within the artistic world to the importance of music as medicine. It is important that musicians realize not only that their art is there to please the ears for the duration of a concert but that it could have a significant and in some cases long-lasting effect on the health of their audience. In a way, there is a parallel between musicians and physicians in that both can induce physiological changes in the people seeking their services (Evans, 2007). Becoming aware of the extent and the nature of these changes may help the musician adjust or adapt the programming of his or her concerts according to the nature of the audience and the effect they want to create in it.

Finally, as detailed in great length above, educating musicians in the field of music and medicine may prevent and minimize the risk of irreversible injuries related to the practice of their art.

Last but not least, educating the general (lay) public about the role that music plays in improving health and helping to treat certain disorders may lead patients to inquire about music and medicine services and request those services from their physicians, if available. Sensitizing the general public to the benefits of incorporating music into the treatment of disease and to the advancements of the research in the neuroscience of music may also favor philanthropic support.

Concert-Symposia and Concert-Lectures

There are different ways of spreading the word and achieving the important education mission of a Music and Medicine program of a hospital. Two effective models are Concert-Symposia and Concert-Lectures. The Concert-Symposia are meetings that include neuroscientists and musicians. The scientists expose the latest research and knowledge status of the topic of music and medicine while the musicians perform at the beginning, within, or at the end of the symposium. This educational format presents the advantage of being extensive, blending science and music into one setting and covering the topic in depth. However, it is elaborate and it requires significant funds to organize. When putting together a Concert-Symposium is not possible, or when a quick broad overview of the topic of music and medicine is requested, the format of Concert-Lecture is a very cost-effective alternative. An example from a personal experience is my collaboration with a concert pianist to present, in about 90 minutes, a program wherein the scientific explanations alternate with live music, hence incorporating the concert experience within the lecture. The purpose of this format is to review the scientific bases of music perception, demonstrate the effect of carefully selected music on the creation and the modulation of emotions, and potentially, with the appropriate technology, measure the changes produced by the music in specific physiological parameters of the listeners, who comprise the audience.

Both types of educational activities target the medical, musical, and general public, and their content can be adapted to the type of audience. They can be organized in hospitals, universities, music schools, music festivals, and private venues.This issue of *Music and Medicine* publishes some of the contents of two educational events that occurred in October 2009. A Music & Health Symposium for Musicians, Performing Artists, and Medical Professionals organized by the Louis Armstrong Center for Music and Health at Beth Israel Medical Center and a Concert-Symposium on Music and the Brain™ organized by the Cleveland Clinic Arts and Medicine Institute at the Lincoln Center in New York City. We hope that through this example of collaborative work, other centers that also focus on the biology of music will follow the lead and will

be encouraged to bring together musicians and scientists for the advancement of our promising emerging field.

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