Karger
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Music & Medicine

EDITORIAL

When the decision was taken to bring out this edition of 'The Gazette' as a commemorative issue for Steven Karger, former CEO of S. Karger publishers, the theme virtually chose itself. Classical music meant a great deal to Steven Karger, who died from cancer in March 2008 at the age of 49. He was a dedicated flautist and also composed choral music. 'Music & Medicine' thus reflects both his private and professional interests.

Steven Karger (1959–2008)

The English composer Edward Elgar is reported to have said, 'there is music in the air,' and at the beginning of the 21st century this is indisputable: on radio and television, at concerts and in the cinema, piped into shopping malls, downloaded onto i-Pods, music accompanies us from the cradle to the grave. Thanks to modern technology, music from all historical eras and from every part of the globe is available to many of us almost instantaneously. We listen to music and we make music – according to anthropologists, no known culture lacks this human propensity to produce, combine and organize sounds.

But why is music so important to us and how does it exert its wide-ranging effects? These are questions that for centuries have fascinated and occupied philosophers, physicists, psychologists, historians and, of course, composers. In the last two decades, neuroscientists have joined the ranks of those probing and theorizing music's functions and modes of action. With the introduction of new tools for studying neurophysiology, it is now possible to investigate what happens in the brain when we listen to or make music. Some of these research efforts – as shown by the contributions to this issue of the Gazette – demonstrate that music is a biologically deeply ingrained function of the human brain and that music is basic to cognitive structure. This research is also providing a scientific basis for the use of music as a therapeutic tool in medicine and rehabilitation. Not only is music processing dispersed throughout the entire brain, but the brain can respond in highly plastic ways to musical input and production, and the continued and intense practice of music can lead to significant structural and functional adaptations in the brain.

The 18th-century German writer and philosopher Novalis wrote that 'every illness is a musical problem – its cure a musical solution.' This may sound like Romantic overstatement and yet, both biologically and therapeutically, there is perhaps more truth in these words than even their author recognized. Putting 'Music & Medicine' together provoked much lively discussion between the editors, and we are deeply sorry that Steven Karger was not here to share with us his reflections and views as this number evolved from the planning stage into the issue you now hold in your hands.

A. Blonstein & D. Horn

The Musical Brain – An Artful Biological Necessity

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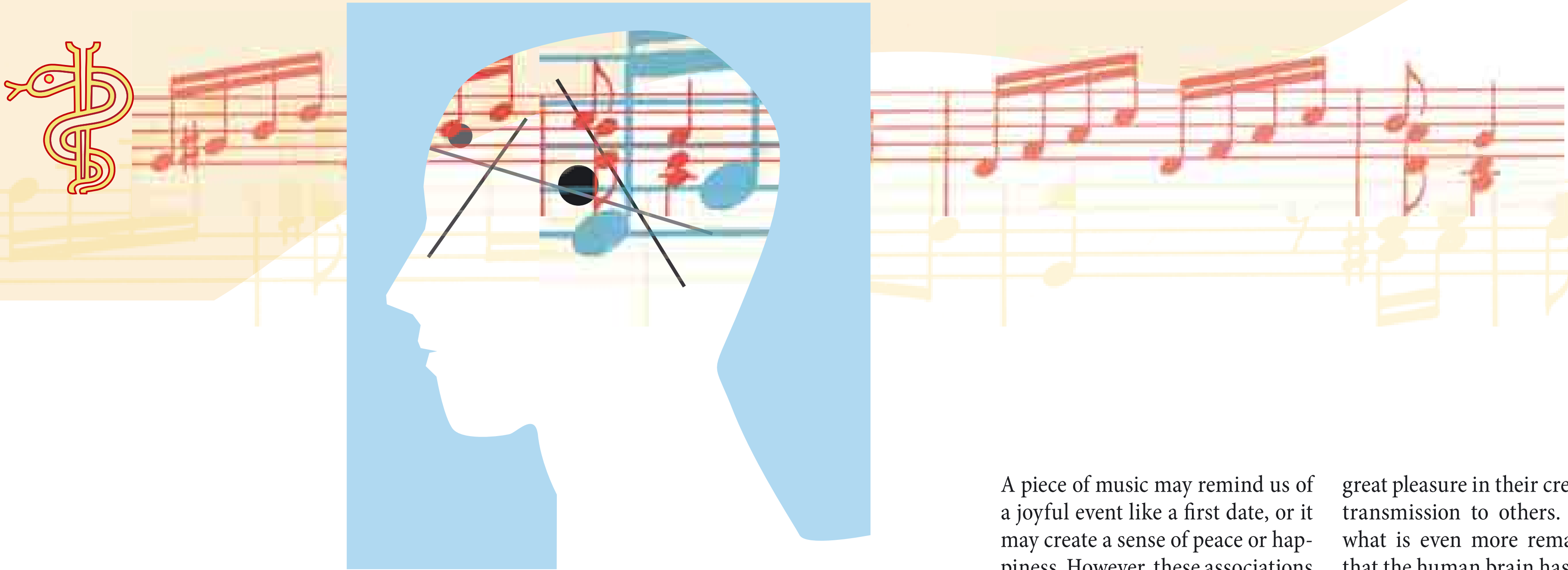

The modern human mind – i.e. a mind with a mental architecture similar to ours – came into being evolutionarily speaking perhaps sometime between 50,000 to 100,000 years ago. The archaeological records show the emergence of artifacts during that period that have to be attributed to cognitively modern minds. What is most fascinating about these records is the overwhelming evidence that, from the outset, these early human minds were artful minds and that artistic behavior was an integral part of human activities.

The Archaeological Evidence

Artworks and the evidence for an engagement in artistic endeavors date back much further than originally thought. Furthermore, this evidence predates that for written language and mathematical codes by tens of thousands of years. Paintings that depict societal functions such as hunting or religious rituals have been the prime archaeological discoveries suggesting the presence of artistic behavior. Cave paintings that strike the contemporary viewer as possessing significant aesthetic quality may be as old as 70,000 years. However, objects like weapons and tools that were shaped with more beauty than required for purely functional purposes have been attributed to humans living 200,000 years ago.

Of course, archaeological evidence for music is much harder to find than sculpted objects or paintings. The physical basis of music consists of temporal sound patterns created by vibrating objects and air molecules. We can therefore only infer from musical instruments the existence and possible sound of ancient music. However, flutes, rattles, whistles and percussion instruments as old as 30,000 years have been found. Rock engravings as old as 16,000 years depict dancers, thus implying the presence of music. Discoveries of musical instruments, at times amounting in number to the size of today's orchestras and created within the last 10,000 years, have been made in many parts of the world, including Egypt, Mesopotamia, Syria, South America, East Africa and China. An ancient set of six wooden pipes has been discovered in Ireland: dated at 4,100 years of age, tuned in octaves and executed in sophisticated craftsmanship beyond the normal Bronze Age levels, they are the oldest wooden instruments to have been found so far in Europe. The archaeologically oldest confirmed musical instrument is a 35,000-year-old bone flute, from Geissenklösterle in southern Germany (Fig. 1).

The oldest excavated figurative artworks – drawings with recognizable images or sculptures of identifiable forms – are over 50,000 years old. The appearance of such figurines in ancient arts marks an important step in the development of the cognitively modern human mind, because figurative artworks begin to embody symbolic representations, that is, the figures have been created to stand for something else. The simultaneous appearance of such highly sophisticated artworks with the emergence of modern human beings during the Ice Age in Europe suggests that artistic abilities did not evolve gradually but may, rather, have come into existence within a relatively short time span.

This evidence for the early existence of fully developed artistry at levels of sophistication, abstraction and representation similar or close to modern art, with little evidence for incremental progression, provokes some startling and provocative hypotheses concerning the role and nature of artistic talent in the human brain. The notion of the arts as the 'icing on the cake' of human brain development – after the basic needs of survival have been satisfied – is seriously questioned by these data. Why did visual art and music emerge as human behaviors? What role and function do they have? Why did art exist at such early stages of human history if it was not necessary for basic survival and societal progress relative to material needs? The archaeological findings imply that artistic engagement as part of human behavior may be much more fundamental to human brain function than originally imagined. The questions may have biological answers after all [1].

Music and the Mind

So what makes music so important for the human mind? Music has frequently been called the most elusive and intangible of the arts. Music cannot express meaning by referring to objects, concepts, events or feelings in a direct, semantically defined manner. It is purely abstract in expression. Certainly, we can learn to associate certain music with particular events or feelings. A piece of music may remind us of a joyful event like a first date, or it may create a sense of peace or happiness. However, these associations are not directly heard in the music. There are no happy chords or angry chords, and there are no pitches that signify joy. There are no melodies that stand for 'love' or translate 'wedding' into music. Recognizing this highly 'immaterial' nature of music, Plato once stated that it must have privileged access to the soul.

However, we are strongly convinced from our own experience that music does have communicative meaning. Music anthropology is full of examples demonstrating how music expresses emotions, concepts or events in specific cultures and societies [2]. Joy, happiness, sadness and loss; rituals of life events such as birth, marriage and death; social and political values and norms can all be expressed through music. But we must remember that in its material sense the communication takes place only through associations and extramusical definitions. Musicians, philosophers and scientists have long puzzled over this peculiar tension in music with regard to how and what music actually can communicate. The visual arts can function mimetically. A painting can pictorially represent war scenes or a wedding celebration; music can express only nonpictorial aspects of such events, and even those only through learned associations. The sound patterns of music cannot depict a wedding ceremony or directly express word meanings, not even for emotions.

Music as a Language of Sound Patterns

What then does music communicate? Fundamentally, music communicates the beauty and temporal architecture of its own sound patterns, and the human brain takes great pleasure in their creation and transmission to others. However, what is even more remarkable is that the human brain has created a very sophisticated and very diverse system of rules or 'grammars' for the assembly of these sound patterns. This process of building very complex musical language codes is only possible because all human beings appear to have the ability to think in abstract 'musical' sound patterns. This brings us to the key point of the argument regarding music and the human brain. The ability to 'think music' is fundamental to the existence of music, it is a universal ability, and therefore probably not learnt but hardwired biologically in the human brain. Without this universal ability, no music would exist, performers would have no audience, infants would not respond to music, and young children would not create music spontaneously.

A useful conceptual shift in our understanding of the nature of music is therefore to recognize that the ability to think music is part of a comprehensive system of mental representations that function in the brain in different modalities. The brain thinks in multiple languages. Verbal language is only one system of thinking, a system in which we think in words. But we also have other languages, for example a language of numbers and quantities, again necessary for thought and reasoning [3]. The nature of the languages of the visual arts and music is based on thinking in nonverbal structures. In music we think, create, perform and listen to aesthetically ordered auditory structures or percepts. The basic ability in music is fundamental to all human brains: we can all think in musical sound patterns.

With this multiple-language model, we can return to some of the questions raised earlier concerning the emergence of music in human culture at the moment when mod-

Fig. 1. The earliest undisputed musical instrument is a bone flute, made from the wing bone of a swan and dating to about 35,000 BC. Its remains were found in the Geissenklösterle, a cave near Blaubeuren in the Swabian Alb (southern Germany). (Photo courtesy of Hilde Jensen, Institut für Ur- und Frühgeschichte und Archäologie des Mittelalters, Eberhard-Karls-Universität Tübingen)

ern minds appear in the archaeological record. The ability to think in abstract symbolic sound structures must have been a critical function in the development of the human brain and its cognitive functions, so important in fact, that it appeared early on with other mental functions such as verbal language. Indeed, music and the arts in general are now proposed as precursors and cognitive prerequisites for the development of higher cognitive executive functions and the emergence of verbal language [4]. Considering music as a core language of the brain may also shed important light on the artistic activities of young children, who will all engage in singing, playing instruments and dance as a normal part of their development. These pursuits become significantly deemphasized in the learning environment when formal schooling starts and 'the arts' become relegated from the cognitive learning core. An interesting question could be raised in this respect: are the artistic pursuits of young children an ontogenetic repeat of a critical evolutionary cognitive development of the human mind?

How Is Music Processed in the Brain?

In listening, creating and performing music, we order abstract sound symbols into highly complex, temporally ordered sound patterns – a process that puts high demands on several mental operations. It challenges our perceptual system in several dimensions because we have to track one or several simultaneous pitches across time forming a single melody or a polyphony. These pitch patterns are structured into rhythmic time patterns. We track and distinguish instruments and voices based on different loudness levels and different timbres or tone colors which are based on the relative presence or absence of overtones in the notes. Overtones are additional pitch or vibration frequencies that are not consciously heard but that any acoustic object produces, because in nature all objects vibrate in multiple frequencies. At the same time – if we are listening to an orchestra, for example – we have to be able to track different sound sources in space. The auditory system is extremely sensitive in identifying differences in sound location.

In any musical task – regardless of its complexity – we have to be able to build a temporally ordered architecture of sound sequences in our mind in extremely rapid succession. Furthermore, music may be the only language of the brain that requires *simultaneous* perception-cognition processing of multiple strands of sound information in tandem with *sequential* comprehension. Finally, music fuses perception and cognition in complex ways – perception of complex sound structures triggers immediate cognitive pattern analysis, integrating perceiving and thinking into unified mental operations. And we may postulate that all these processes may be foundational to higher cognitive functions in general and the emergence of comprehensive intellectual development.

The Philosophy of Music Meets the Neurosciences

If this sounds far-fetched, we may need to remember that our modern focus on music and the arts as carrying their foremost value in pleasure and entertainment, beauty and emotional expression is a relatively recent one shaped largely by the Romantic movement of the early 19th century. A closer look at philosophical views on music, however, reveals a long and continuous tradition of integrating music into models of scientific and philosophical thinking.

The earliest record of musical notation comes from the Sumeric culture 3,500 BC in Mesopotamia, using a 60-count numerical system to determine pitch frequencies and ratios. This system was deeply embedded into the mathematics and the religious symbolism of the culture and was probably still available to Plato (428–347 BC), whose philosophical thinking is still unique in human history by being deeply embedded in musical thought.

In classical Greek culture, music was part of the natural sciences. Plato emphasized – in a way similar to Confucius in China – the educational value of music, noting its ability to offer insight into the natural sciences and also to train the mind and intellect in general. He acknowledged the power of music to stir emotions (and was deeply suspicious of this power), and therefore stated in the famous dialogues in *The Republic* between Socrates and his young follower Glaucon the need to include in his perfect and ideal state only music that evokes praiseworthy emotions characterized by virtue, courage and restraint. Music, as a nonimitative art form, fared better in Plato than poetry and painting, which he considered as imitative art forms that are equally or even more dangerous than music in their ability to influence human character emotionally.

Almost 900 years later, Boethius (died AD 524) – a philosopher living at the transition between the decline and destruction of the classical world of the Roman Empire and the emerging period loosely described as the Middle Ages – summarized these multiple functions and understandings into a threefold division of music. *Musica mundana* is the reflection of the Pythagorean notion of music as a natural science with an intrinsic structure that embodies knowledge about the physical structure of the universe. *Musica humana* refers to the harmony between body and soul, perhaps a concept inspired by the educational and cathartic values ascribed to music by Plato and Aristotle. The lowest role for music lies closest to our modern understanding of music, in the form of *musica instrumentalis*, music as actual sound, sung and played. These subdivisions proved to be extremely influential in shaping a philosophical view on musical aesthetics, and Boethius' notions dominated music theory for over ten centuries.

A new reading of Immanuel Kant's (1724–1804) *Critique of Judgment* (1790), the third of his three famous *Critiques*, within the contemporary context of an emerging cognitive neuroscience of music may make his views surprisingly relevant for our current discussion. Kant's formulation of innate *a priori* knowledge – i.e. a knowledge not driven by external sensory-based learning – as a basic cognitive structure and mechanism imposed on perception and reasoning is echoed by notions of innate cognitive architectures put forward by modern theorists in cognitive neuroscience who are studying the neural substrates of cognitive processing.

For Kant aesthetic judgment comes from a specific form of pleasure through the 'disinterested' and objective contemplation of an art object. Kant states that the source of pleasure is related to the features of the object that are uniquely suited to an individual's perception. Kant claimed that the imagination (i.e. the mental faculty that allows one to apprehend the art object) and cognitive understanding (i.e. the faculty of comprehension and conceptualization) resonate in a synchronized perception-cognition process. It is as if the art objects were produced in order to be heard or seen by the perceiver. This view assumes so much innate *a priori* artistic thinking and reasoning ability that it seems defensible nowadays only in the context of modern brain science, which would assign to art a biological basis in brain function.

Music and Brain Research

With a model of music as an autonomous biological language of the brain as a working hypothesis, it is very interesting to look at the enormous amount of excellent brain research undertaken in the past 25 years. One immediate question that comes to mind within this model would be how brain regions involved in verbal language are distinct or similar to brain regions processing music. Brain research has shown that there is distinctive and shared neural circuitry between the two systems. In general, speech comprehension and speech production are more focally organized, predominantly in the left brain hemisphere, although the right hemisphere is active in speech encoding and decoding. The multiple elements of music processing are distributed much more widely across brain regions in both hemispheres. In addition, neuropsychological research with individuals with brain injuries has shown that linguistic syntactical and musical syntactical (rule-based) abilities can be dissociated, one can occur without the other [5]. However, neuroimaging research has also shown very interesting overlaps in activated brain areas for both speech and music. For example, similar electroencephalographic brain wave patterns were discovered in response to rule-based syntactical violations during musical and linguistic tasks [6]. Furthermore, similar areas in the dorsolateral prefrontal cortex are activated during musical improvisation/composition and linguistic verbal tasks like storytelling and sentence completion. A fairly large number of studies have shown the existence of shared networks between verbal language and musical language particularly in the inferior prefrontal gyrus regions (Brodman areas 44–47) that include Broca's area, which is strongly involved in speech encoding. Damage to Broca's area results in expressive aphasia. These regions may be involved in rule-based syntactical knowledge in both linguistic and musical knowledge. They may also be critical systems to mediate sequencing in perceptual, linguistic, musical and motor tasks. Thus, one may consider these regions as supramodal processing centers for syntactical knowledge and complex sequencing. These areas are also activated during rhythmic synchronization tasks, possibly mediating complex temporal motor and perceptual processes. Consequently, it may be a reasonable proposal that training and shaping this supramodal network using all languages of the brain, including music, may have a broad impact and potentially cross-modal effects on general cognitive fluidity and other behavioral and cognitive operations that draw on this network [7].

'Music is part of our nature and has the power to ennoble or degrade us.' Boethius

(Musicam naturaliter nobis esse coniunctam et mores vel honestare vel evertere.)

Recent experiments in our laboratories at Colorado State University have explored the connections between linguistic and musical tasks. In one study, we used the 'recognition without identification' paradigm, in which subjects are initially asked to learn word lists and are subsequently presented with the same word list with new words mixed in; however, all the words are fragmented by the removal of several letters. Typically, despite the fragmentation, subjects recognize as familiar more of the previously learned rather than the unlearned words. We translated that paradigm into a musical task where we fragmented melodies either by randomly removing notes or removing every other note in a melodic sequence. Results for recognition of musical fragments as familiar – although subjects could not identify the actual melodies – were very similar to recognition of word fragments, possibly showing similar perceptual recognition mechanisms for abstract musical sound patterns and verbal language patterns.

In another currently ongoing study we are investigating musical ability tests as predictors for cognitive test performance. In statistical regression analysis, among musical abilities, only rhythmic ability has

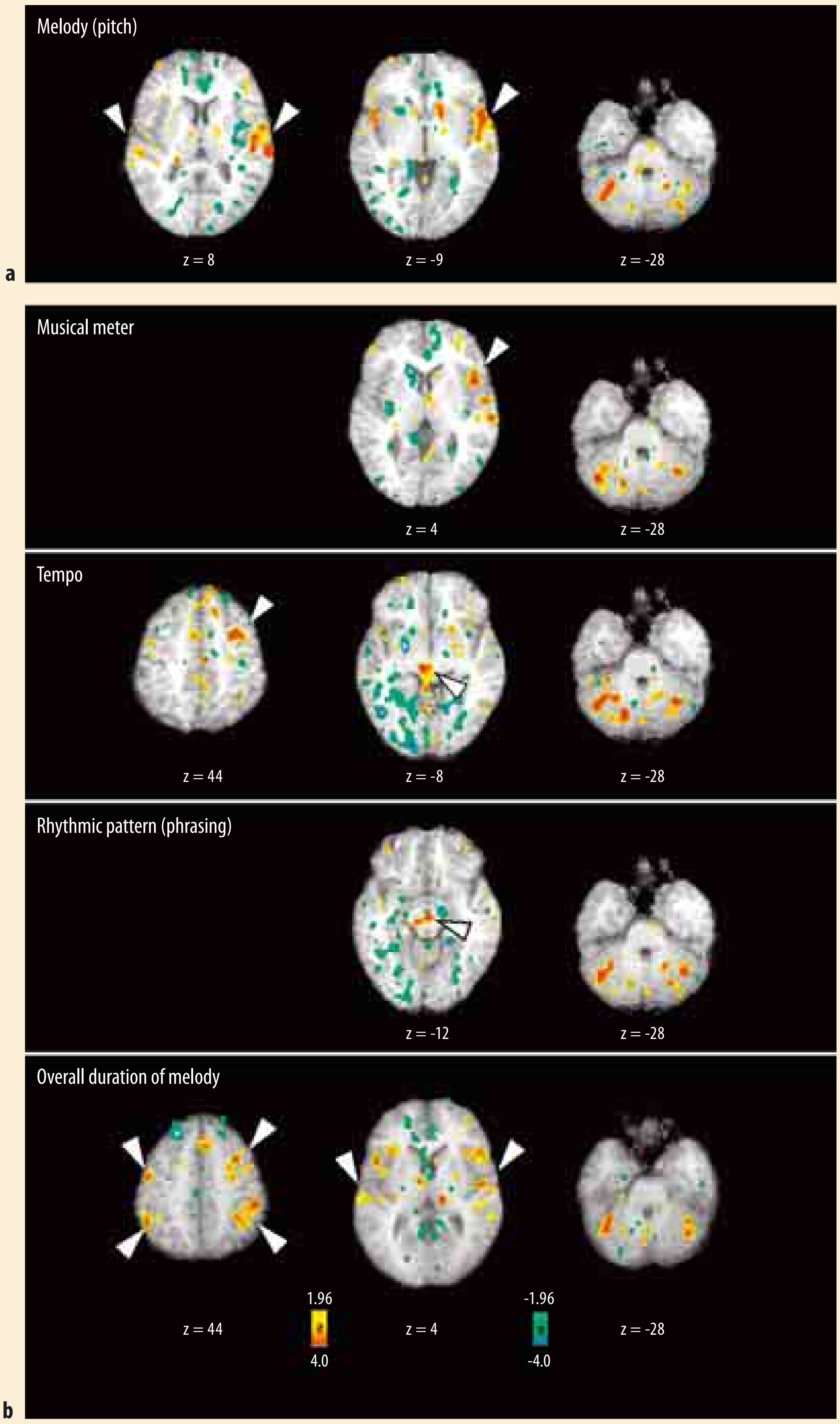

Fig. 2. The neural basis for musical rhythm is a highly complex and modular network system. Shown in these positron emission tomography scans is the brain architecture for perception of melodic contour **(a)** and different components of rhythm perception **(b)**. Measurements of oxygenation changes in the brain are an indicator of activity levels of brain structures: the yellow to red scale indicates increased activity, and the green to blue scale, reduced activity relative to the control situation. These scans show not only differences in primary activation areas between melodic and rhythmic perception networks in the brain, but also that the different musical components of rhythm perception (meter, tempo, pattern, duration) activate distinct networks.

been found to be a significant predictor for cognitive ability. Furthermore, strong rhythmic ability correlates with high scores in verbal ability but not in mathematics.

The Centrality of Rhythm

Rhythm – most broadly defined as an ordered distribution of temporal events – is a key component of musical language because it creates the temporal harness for the melodic and polyphonic elements. Within such a general definition, music without rhythm cannot exist. Metrical rhythms are a specific subform of rhythm as ordered time. Metrical rhythms in music are based on felt pulse patterns on which more complex time patterns are built, e.g. subdivisions in meters, fixed repetitive rhythm patterns in modes, or ostinati (varying melodic rhythms). The language of rhythm is extremely diverse across musical cultures, suggesting that the brain has very distinct abilities to build temporal architectures in music. While the melodic time flow of early medieval melismatic singing and chanting followed no fixed beat patterns, Western music has evolved to be organized in fixed time signatures (e.g. 3/4, 4/4 meters). West African music is built around complex polyrhythms. Indian Raga music consists of long rhythm patterns of up to 128 beats that repeat themselves throughout a piece. Furthermore, rhythm is not a singular term, it encompasses a number of time elements and time-creating devices such as pulses, beats, meters, accents and higher-order time units.

To study the neuroanatomy of complex musical rhythm perception, we first looked at meter, pattern, tempo and duration separately in discrimination tasks, and compared their anatomical distributions with those activated during a pitch discrimination task embedded in a complete melody sequence (Fig. 2) [8]. The results showed that the pitch/melodic contour system is separate from the rhythm perception system in the brain. In nonmusicians, pitch/melody discrimination activated right auditory cortex regions. Each rhythm component showed a different neural brain network subserving the different rhythmic elements. Meter prominently activated inferior frontal gyrus regions, pattern discrimination was mediated by activations mostly subcortically in midbrain regions, tempo discrimination activated prefrontal areas, and the duration judgments activated additional areas in the inferior prefrontal gyrus region. All tasks showed significant involvement of the cerebellum, demonstrating that the cerebellum is not only important for motor control but also for complex sensory perception without any movement. One of the most interesting insights from this study may be that the partial separation of networks in the brain subserving each rhythm function constitutes the neurological basis for the brain to be able to create very different rhythmic languages and vocabularies across music cultures.

The broad and widely distributed neural architecture of rhythm processing seems to emphasize its special role as a critical syntactical element in musical language. This critical role is accompanied by remarkable effects of rhythm on the human nervous system. We and other researchers have shown how auditory rhythm entrains movement patterns, i.e. drives them into the same frequencies, rapidly and precisely [9]. This entrainment effect can also be demonstrated when subjects tap their fingers or move their arms to rhythms that fluctuate in tempo so slightly that the tempo changes are not consciously audible. Despite the lack of conscious awareness, the subjects' finger taps will follow the subtle tempo changes in precise synchronization. We also discovered that rhythm is a highly effective stimulus to retrain movement ability in patients with stroke, Parkinson's disease and other motor disorders. Research over the past 15 years has shown impressively that auditory rhythm can be a very effective sensory timer or template to improve, for example, speed of walking and arm movements, stability of movements, as well as temporal and spatial precision and coordination in neurologic rehabilitation [9].

Finally, if we conceptualize music as a language of thinking in sound that is deeply ingrained in the emergence of early human cognition, it may also come as no surprise that recent studies show that the ability for temporally precise rhythmic performance has been associated not only with increased scores on general intelligence tests but also increases in white matter volume in the prefrontal cortex [10]. And the accumulating evidence that musical training is associated with increases in academic and other cognitive abilities may indeed point to music and the arts as critical languages of the brain that train the brain's cognitive and perceptual systems in autonomous yet foundational ways. Furthermore, this view opens a very new avenue into understanding how music can operate in therapy and medicine. Instead of being an auxiliary system for emotional and relationship support, it is a brain language that can help re-educate perception, cognition and movement in the injured brain [9].

The evidence is now strong that the early human brain was an artful one not as an accident or overflow development from other functional mental developments with little practical use. Quite the contrary: the artfulness and musicality of the human brain may have been the foundation for the emergence of the modern human mind.

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Michael H. Thaut is Professor of Music and Professor of Neuroscience at Colorado State University and serves as Co-Director of the School of the Arts and Director of the Center for Biomedical Research in Music. His research focuses on brain function in music, especially time information processing in the brain related to rhythmicity and biomedical applications of music to neurologic rehabilitation of cognitive and motor function. Dr. Thaut has authored and co-authored several books which have been translated into German, Japanese, Korean, Italian and Spanish. Before he became a neuroscientist and music therapist, he was a professional violinist in the classical and folk genres.

Music as Therapy

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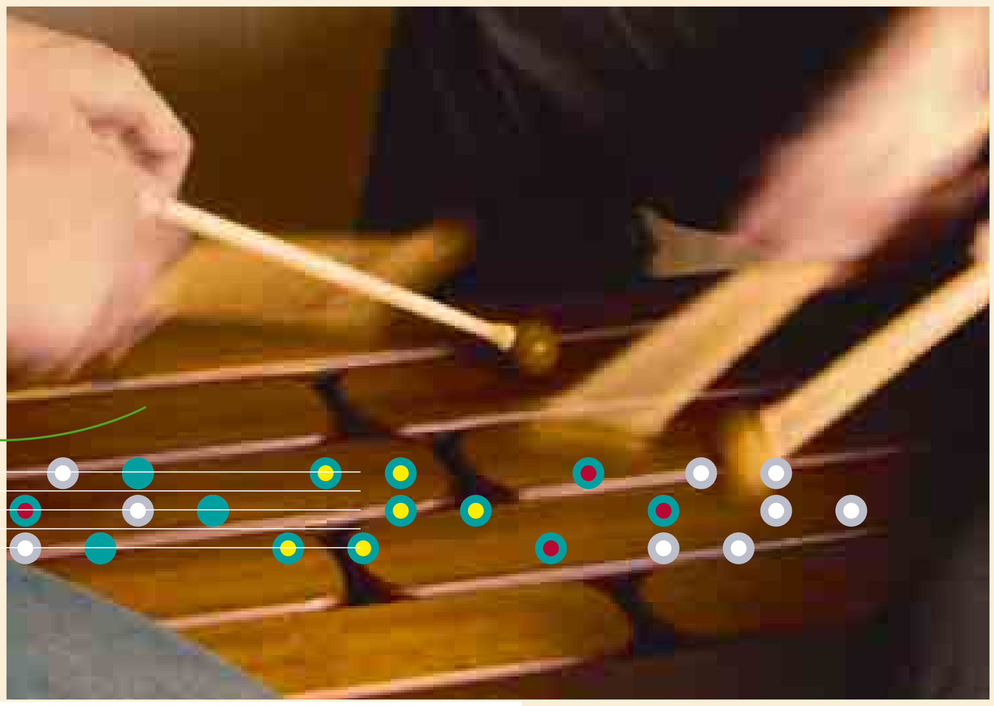

It's a familiar scenario for many: at home watching a thriller on television, as the tension becomes almost unbearable, a hand involuntarily reaches out for the remote control to turn down the volume or even switch off the sound – and suddenly, the nerve-wracking images become tolerable. Such behavior illustrates the powerful effects of sounds, noises and indeed music on our brains. And it is precisely the keen sound-processing abilities of our minds that are harnessed for modern forms of music medicine or music therapy.

A basic concept underlying the use of music as a therapeutic agent is that a phenomenon able to generate tension can also assist in reducing it. In other words, music can relieve stress and promote relaxation. Emotional states and pain sensitivity are also susceptible to modification through music. Facilitated by trained musical therapists, many patients by either actively making music or listening to it can achieve significant therapeutic goals.

The Development of Modern Music Therapy since 1945

It was in the United States after the two world wars that music therapy as we know it today began to take shape. Musicians visited veterans' hospitals around the country to play music for the thousands suffering from post-war physical and emotional traumas. Doctors and nurses observed the benefits of these activities and requested the hiring of musicians by the hospitals. It was recognized that they required training in how to apply music for therapeutic purposes, and so colleges and universities began to set up specific music therapy curricula and programs. In 1944 the first music therapy program in the world was founded at Michigan State University, and 1950 saw the founding of the first professional association for music therapists, the National Association for Music Therapy (NAMT). Subsequent changes in the structure of the American health care system necessitated the fusion in 1998 of the NAMT with the second-largest association at that time to create the American Music Therapy Association (AMTA), still today the country's major professional organization for music therapists. The first European association, the British Society for Music Therapy (BSMT), was founded in 1958.

The first World Congress for Music Therapy took place in Vitoria, Spain, in 1973. The ground for a global association of music therapists was prepared in 1976 at the next World Congress in Buenos Aires, Argentina, and the World Federation of Music Therapy (WFMT) finally saw the light of day at the fifth World Congress in 1985 in Genoa, Italy. A European Music Therapy Confederation (EMTC) was formed in 1990. One of the major goals of the EMTC was to bring on a par with one another the various training programs within Europe and especially within the European Union.

Receptive music therapy using the monochord at the patient's bedside in an acute medical situation at the Tumor Biology Center in Freiburg, Germany

The application and validation of music therapy as an officially recognized form of medical treatment varies greatly among national health care systems. In most countries, music therapy is still not regarded or accepted as an independent medical discipline. Instead, most music therapy approaches are offered within the context of health care and welfare clinics and institutions that treat and cater for a broad spectrum of conditions and diseases.

There are exceptions. In Austria in 2008, the draft of occupational licensing regulations for music therapy was unanimously accepted by parliament, laying the foundations for legal recognition of the profession.

Given the absence of such statutory provisions when the various associations were first established, the ways in which music was applied for therapy to begin with were shaped by the various and competing schools of psychotherapy, ranging from cognitive behavioral therapy to approaches based on depth or gestalt psychology. Gradually, though, music therapy developed an independent identity, and with a growing awareness of the specific features and qualities of music, music therapists began to distance themselves from the domination of existing psychotherapeutic premises in their theory and practice. In addition, attention was increasingly paid by basic research to the specific modes by which music acts on the mind and the person.

Thus, after years of differentiation, a new professional unity has now been achieved. This is reflected and underpinned by, for example, the fusion of the two American associations in 1998, and the merging in 2008 of the largest German music therapy associations into the German Music Therapy Society.

The Current Definition of Music Therapy

According to the WFMT and the AMTA, music therapy can be defined as the clinical and evidence-based use of music and/or its elements (sound, rhythm, melody, harmony, dynamic, tempo) by a qualified music therapist to accomplish individualized goals within a therapeutic relationship with one client or a group. The aim of music therapy is to develop potentials and/or restore functions of the individual so that he or she can achieve better intrapersonal and/or interpersonal integration, which may include a better quality of life, through prevention, rehabilitation or treatment.

Besides its scientific orientation, modern music therapy defines itself as a resource- and relational-based approach. It is an established health profession in which music is used within a therapeutic relationship to address individuals' physical, emotional, cognitive and social needs. After assessing the strengths and needs of each client, the qualified music therapist provides the indicated treatment including creating, singing, moving to and/or listening to music. Through musical involvement in the therapeutic context, clients' abilities are strengthened and transferred to other areas of their lives. Music therapy also provides avenues for communication that can be helpful to those who find it difficult to express themselves in words.

A distinction needs to be drawn here between music therapy, which always involves the participation of a qualified music therapist, and the concept of music medicine, in which music is employed as an ancillary therapy by those who are not necessarily specialized in the field.

How Does Music Exert Its Effects?

Until the 1990s, scientific evidence for the value of music therapy was sparse and unsatisfactory. Up to that point, the majority of publications were case studies, and these were only complemented in the last decade of the 20th century by a growing number of clinical studies and reviews. This growth continues, and a search for relevant titles in databanks such as PubMed or PsycINFO reveals that about one-third of the articles on music therapy have appeared within the last decade. The first Cochrane meta-analyses [1] and systematic reviews [2] have demonstrated that music therapy works and that it is as effective as recognized psychotherapeutic approaches.

In their review of ten meta-analyses and four reviews from 1986 to 2005, Argstätter and colleagues [2] found that music therapy was especially effective when applied with neonates, children with autism, and children and youths with psychopathologic problems. Music therapy also demonstrated good but less consistent success with other conditions, including dementia and psychosis, and for stress reduction.

Recent imaging studies, such as those employing positron emission tomography (PET), have shown that some of music's effects are specifically elicited by the sites and ways in which it is processed by the brain's neuronal network. Such processing can influence and alter, for example, our emotional experiences [3] and the perception of pain [4].

One of the biggest surprises during early observations of those with brain damage or of healthy subjects with amusia (the inability to recognize and replicate musical tones or rhythms) was that there is no special music center in the brain. Rather, when listening to or making music, several areas distributed throughout the brain are activated, including some that are typically engaged in other cognitive functions, such as the Broca area, which is responsible for the comprehension and production of the grammatical aspects of language.

In his book published in 2003, *Musik im Kopf [Music in the Brain]* [5], the psychiatrist Manfred Spitzer describes graphically the results of a study first published in *Nature* in 1993, which came to be known as the 'Mozart effect.' In fact, it would be more accurate to ascribe this effect to the publication of the article rather than the research findings themselves: on the day after the article appeared, sales of Mozart recordings – and in particular of the Sonata for two pianos in D major (KV 448) used in the study – soared.

Active music therapy using African drums. The musical dialogue between patient and therapist is played improvisationally, simultaneously and fully spontaneously.

What had been studied, and does Mozart's music have clinically relevant effects? Rauscher and his colleagues [6] investigated whether listening to music had an impact on the processing of spatial perception. Thirty-six students were divided into three groups. One group listened to the Mozart sonata for 10 minutes. The second group were played relaxation music for the same period. The third group received no acoustic stimulation. Afterwards, the subjects' spatial intelligence was evaluated with a standardized test. Students who had been listening to Mozart achieved significantly higher scores than those in the other two groups. This study provoked various responses. US schools began to play Mozart in the background during lessons, while a flood of studies and a critical re-examination of the Mozart effect appeared in the scientific press. So, is there a Mozart effect? In a strictly scientific sense: no; that is, specific pieces of music have no effect on cognitive development. Nevertheless, the processing and production of music are highly complex activities that place great demands on our brains. Simply consuming music is unlikely to promote mental abilities without additional individual input or initiative. Furthermore, making music challenges us at many other levels, including our fine motor skills, memory and responsiveness to stimuli. It trains not only human cognition, but at the level of personality, how we deal with our emotions, and it is an important resource for learning self-discipline.

From a therapeutic perspective, particularly interesting are the events that take place in the brain when we react emotionally to music. Most people experience somatic reactions when they respond strongly to pieces of music. In a study by Sloboda in 1991 [7], the most commonly mentioned reactions were a shiver of goose bumps running down the spine, laughter, a lump in the throat, tears, or an increase in heart rate.

Music does not merely evoke emotions, for many it is a vital component of a full emotional life. Patients often describe how since childhood, as well as during serious illnesses, music has helped them to work through emotional stresses. Just a few minutes sitting at the piano playing a piece of music can relieve emotional strain. Serious physical illness is often accompanied by a marked degradation of one's sense of well-being, which in turn undermines and interferes with a person's usual involvement with music. Being able to make music again is often experienced by music therapy patients as a way back to (an often readjusted) normality.

In a PET imaging study, Blood and Zatorre [8] were able to show that music stimulates neuronal systems that otherwise respond to food intake, sex or narcotic drugs. The body's reward system is stimulated, leading to the release of endogenous opioids and the neurotransmitter dopamine. Furthermore, music that is experienced as pleasant inhibits central nervous system structures that signal anxiety, aversion or pain. In parallel, Blood and Zatorre also found activation of structures important for wakefulness and attention. This is interesting given that, strictly speaking, music is necessary neither for survival nor reproduction and is not itself a pharmacological substance. Their study, however, underscores the experiences described above: we may be able to live without music, but without music our psychic health may be considerably impaired.

Another approach in music therapy research and one that is closely related to chronobiology is the study of heart rate variability during music reception and active music making. Changes in relevant physiological parameters are measured with small instruments that do not, or only slightly, interfere with the subjects' mobility. The variation in our pulse is an indicator of our degree of relaxation and physical equilibrium. In sports medicine and competitive sports this measurement is used, e.g., to monitor an athlete's condition and to prevent excessive training. If the variation drops off and the heart beat takes on the characteristics of a metronome, these are interpreted as danger signals. People in stressful situations exhibit less heart beat variation than those who are relaxed. Studies of pulse variability of patients in palliative care show that towards the end of life, the heart beat becomes increasingly regular, with virtually no variation. As far as music is concerned, both listening to music and active music making, like singing, raise heart rate variability and contribute to somatic recovery and a reduction in stress and tension.

Musical activity can alter not only the variability of the heart beat. In a study with cancer patients suffering from chronic pain, Reinhardt [9] showed that the patients' pulse synchronized with the beat of slow relaxation music. In addition, over the course of several sessions with this music, the patients self-administered significantly less analgesic medication. Two synchronization relationships were found: 1:2 (music 50 bpm, heart 100 bpm) and a particularly stable one of 2:3. The latter was found when the music had a tempo of 42–48 bpm – the heart responded with a pulse of 63–72 bpm. Those patients who enjoyed the music most tended to show the greatest degree of synchronization.

Important information about the effects of music can also be obtained by directly interviewing patients or giving them questionnaires to fill out. A study with patients undergoing oncological rehabilitation in the Clinic for Tumor Biology in Freiburg showed that the relatively monotonal but overtone-rich sounds of a monochord (a 30-stringed instrument with three tonic notes) promote a feeling of calm and equilibrium [10]. Especially noteworthy here is that the music exerts its effects almost immediately and the patient does not have to practise a listening technique.

Music as Therapy

There are fundamentally two types of music therapy: active and receptive. In active music therapy, the patient makes music either alone, with a therapist or within a group. In receptive music therapy, the therapeutic goals are pursued exclusively by listening to music. Music therapists work with the underlying assumption that everyone is endowed with a basic musicality, a hypothesis that, as Michael Thaut has shown in his opening article, is now substantiated by a significant body of research. Music therapy, and this point needs to be stressed, requires no prior musical knowledge – such as the ability to play an instrument – on the part of the patient. In fact, when trained musicians are in therapy, there is often the danger of their running into conflicts with their personal aesthetic standards. Having an open mind about music and how it is employed in therapy is, rather, much more likely to lead to a successful outcome.

When, for example, patients in an active group therapy at the Clinic for Tumor Biology in Freiburg are able to stop worrying self-critically about how well they are performing and are simply able to enjoy what they are doing, they are then able to achieve a greater sense of composure, can actively reduce the stresses they are experiencing and, in general, reach a higher degree of self-acceptance. In the oncological context this often also means a new relationship to the injured self, or even a new body identity – important healing outcomes when coming to terms with a cancer illness.

Table 1. Clinical fields and conditions suitable for treatment with music therapy, with the authors' evaluation of the validity of active versus receptive therapeutic modes (●●● = high, ● = low)

Clinical field	Selected conditions/goals	Active	Receptive
Psychosomatics	Tinnitus, pain, burn out, stress	●●●	●●
Psychiatry	Depression, schizophrenia	●●●	●
Neurology	Stroke with hemiparesis, memory performance, fine motor action, fine motor function in speech	●●●	●●
Oncology	Illness adjustment, audioanalgesia, anxiety reduction, life quality, expression of emotions	●●	●●●
Pediatrics	Autism, anxiety reduction, migraine, neonatology	●●●	●
Gerontology	Dementia, reduction in agitation	●●●	●
Palliative medicine	Audioanalgesia, anxiety reduction, terminal care	●	●●●

Table 2. Methods in music therapy

Receptive music therapy		Active music therapy	
Relaxing, palliative	Rehabilitative /functional	Reproductive	Productive
• Live at the bedside • Sound meditation	• Guided imagery and music • Functional music therapy	• Singing songs • Work with rhythm	• Assisted composition • Improvisation

The areas in which music therapy can be applied can be broadly subdivided into clinical, pedagogic and gerontologic applications. The clinical scope is wide and includes psychosomatics, psychiatry, neurology, oncology, pediatrics, gerontology and palliative medicine. Table 1 shows the clinical fields and medical conditions in which music therapy is applied, and rates the value of the two therapeutic forms – active and receptive – for the different fields.

The Methods of Music Therapy

Active music therapy can take the form of either a reproductive music therapy using well-known songs or rhythms, or a productive music therapy during which new musical pieces are created spontaneously or are composed. Regardless of the method, the goal is to promote emotional expressivity, accompanied by a general psychophysiological activation and stimulation of the patient's creativity. For a patient with a chronic disease, for example, these are all processes that will assist him or her to cope with the disease. Receptive approaches may (a) be relaxational and palliative, for example, to reduce pain; (b) be more rehabilitative and psychotherapeutic; or (c) have a functional orientation (see Table 2).

Active Music Therapy

Active music therapy usually works with instruments that are very easy to play. The aim here is not for the patient to learn to play an instrument well or perfectly. The goals, rather, of active music making are to improve the patient's communication and relational abilities, to mobilize and activate the nonverbal expression of emotions, to overcome restrictive personality patterns or simply to experience joy in doing something for oneself.

For patients under substantial stress, such as those with a progressive chronic disease, active music making can help them gain some distance or respite from negative thoughts and feelings because their attention becomes totally absorbed by the music making activity. Oncology patients, in particular, have explained how helpful and agreeable this can be.

Typical intervention techniques in active music therapy are singing, playing with rhythm, improvisation, and the composition of music or songs. These methods are described in more detail below.

Singing

Working with songs obviously involves the use of the patient's own body as the musical instrument. In the therapeutic context, singing can train articulation, breathing and individual expressivity. Group work, in addition, nurtures the development of social skills. In particular, people with dementia can regain some of their lost speech abilities by singing well-known songs. At the same time, singing can help to relieve the anxieties associated with dementia. For patients with an aphasia after stroke, singing can stimulate the brain's speech centers, leading to a subsequent improvement in speech competence.

Rhythm

Working with rhythms during therapy enhances fine motor skills and eye-hand coordination. The expressive power that is often released by rhythm work contributes to an active release of tension, flow (the mental state in which a person is fully immersed in what he or she is doing), and in groups to a positive sense of belonging, manifested in pleasure in one's own activities. Rhythm as well as the experience of an inner metrical beat can be, as mentioned above, beneficial for health-promoting synchronization processes and are even able to stimulate the motor areas of the brain.

Stroke patient doing rhythmic auditory stimulation-based gait training with a metronome and a physical therapist at the Center for Biomedical Research in Music, Colorado State University (photo courtesy of Michael Thaut).

Improvisation

In musical improvisation, patients express thoughts and feelings wordlessly. It is a therapeutic technique in which they can deploy their creativity, responding to and interacting with their own performance or that of a group. Improvisation implies the *extempore* – something out of time and unprepared – i.e. engaging with the unpredictable, as all of us are challenged to do in our everyday lives when we must draw spontaneously on our own resources, make on-the-spot decisions, or react to situations in unexpected ways. One of the aims when the therapist and patient review what has taken place during an improvisation session is to identify those aspects of the music making that the patient him- or herself experiences as particularly useful. For an outsider, such improvised music often sounds strange, cacophonous. Patients too usually need some time to adjust themselves to and feel comfortable with the improvisation set-up. Improvisation is often used as a psychotherapeutic approach when words fail and emotions are hard to express. It helps to dissolve emotional blocks, and through it patients can relearn to trust their ability to interact withothers.

Composition

Composition is used in music therapy to express feelings, to experiment with music but also to counteract the ephemerality of music by creating a mental and emotional anchor. In the pediatric setting, for example, children may rewrite the words to their favorite songs in order to understand or express their fears and to gain courage in facing them. During terminal care, composition provides a space to explore fundamental questions about life, dying and death. Such patients may write pieces as a legacy for the most important people in their lives, expressing their love, gratitude and appreciation. In work with adults, writing the melodies and texts of songs can help to thematize painful experiences and address traumas. During the composition process, discussion with the therapist helps the patient to assimilate the topics that are relevant to the therapy and then feed these reflections back into the creative artistic practice.

During an oncological rehabilitation, one of our patients wrote the song 'Feeling Well Again.' Two years later, in good health, he returned to the Clinic for Tumor Biology for consolidation therapy. He had programmed his tune as the ring tone for his mobile phone. Every time he received a call, it reminded him of his resolution to take care of his health and to think well of himself. This raised not only his spirits but also that of his family and friends.

Receptive Music Therapy

In receptive music therapy, music is used for purposes of relaxation, to reduce pain, relieve anxieties and/or to stimulate illness- and therapy-relevant psychic processes. The patient listens either to music played live by the therapist or to recorded music. Listening to music can also have additional functional neurological effects through the stimulus of rhythm or a metrical beat.

Palliative/Relaxational

The goal of relaxational music therapy is to procure psychophysical relaxation through listening to music. In the Clinic for Tumor Biology in Freiburg, for such therapy we employ the monochord, a 30-stringed instrument, played live by the therapist. In group work we refer to this approach as sound meditation. It enables many patients who encounter problems with other relaxation modalities to achieve an intense experience of deep relaxation and inner peace.

Receptive music therapy can also be applied at the bedside. Especially in situations – such as the approach of death – when anxieties may be strong, music can bring about both physical and psychic relaxation (anxiolysis) and may reduce pain (audioanalgesia). When other senses are closed off (sight for example) or numbed by medication, through the ear, music can often still reach the body and 'soul' of the sick person.

Rehabilitative

Here music is used to support processes of self-discovery and psychotherapy. One established method is guided imagery and music. Usually classical music is employed as a sound setting to bring forth inner images, ideas and memories that are subsequently discussed, assimilated and therapeutically integrated by the patient.

Functional

Applied appropriately, listening to stimulating music, a simple rhythm or even just a regular beat can have therapeutic benefits. During physiotherapy following a stroke, for example, listening to a metric beat can facilitate the relearning of certain gait functions such as walking speed and step length [11]. Thaut and his colleagues [12] have also been able to show that an acoustic-rhythmic stimulus can improve the movement and speech motor control of patients with Parkinson's disease.

Coda

Today, even in fields of medicine strongly dominated by evidence-based approaches, music, with or without a therapist, has become a scientifically proven 'remedy' that offers patients a nondrug, complementary medical treatment. Music can be applied to enhance the sense of well-being, to reduce stress, to express feelings without words, to improve interpersonal communication, to stimulate memory performance and to relieve pain.

Music therapy is now rapidly shedding its exotic status and developing into a serious, scientifically based discipline with a broad range of therapeutic options. One of the most important prerequisites for an effective therapy is that the patient enjoys what he or she is doing and hearing. Under these conditions, music can unfold its healing powers.

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Hans Helge Bartsch is a specialist in internal medicine and hematology/oncology. For 30 years, he has treated cancer patients, from primary diagnosis through to palliative and terminal care. His research focuses on improvements in therapy, especially the development of interdisciplinary therapeutic concepts to ameliorate illness- and therapy-related problems. Since 1993, he has been Medical Director of the Tumor Biology Center at the Albert-Ludwigs University in Freiburg, and spokesman of the board there since 2005.

Music and Healing from Antiquity to the 20th Century

The uses of music for therapeutic purposes probably date back into the prehistoric mists of human culture. Music has always been associated with magic and with religious rites, and men and women with special powers are likely – as do their counterparts in many contemporary cultures – to have used music to invoke the gods, hypnotize patients and, indeed, to assist the sick body to heal. However, a history of music therapy in the west must draw – in the absence of any other evidence – almost exclusively on written sources and has to be careful to distinguish theory from practice. From antiquity onward, the authors who mention or advocate the therapeutic potential of music have tended to be philosophers and musicologists rather than physicians, and there is far more evidence for music therapy as an ideal than an actuality.

Pythagoras (died c. 500 BC) is credited with having identified mathematical ratios in music and developing the notion of 'the harmony of the spheres,' i.e. that the planets and stars move according to mathematical equations which correspond to musical notes and produce a symphony. Corollaries were then drawn with the human body and soul, along with the idea that the appropriate music could maintain or return the performer or listener to a harmonious state. Pythagoreans did apparently use music systematically for therapeutic purposes: they would sing and play the lyre when they rose in the morning so that they started the day bright and alert, and again at night to carry away the day's cares and prepare them for propitious dreams.

Plato (died 347 BC) embraced much Pythagorean doctrine in his writings. In the *Republic*, the concept of harmony is used to characterize psychological and social order, and philosophy itself is seen as a musical activity. It was such Platonic conceptions that were taken up in the Middle Ages by writers such as Boethius, discussed in Michael Thaut's article. One of Plato's pupils, Xenocrates (died 314 BC) is said to have used instrumental music to cure hysterics. The effect …

(Continued on page 12)

Apollo's Gift and Curse: Brain Plasticity in Musicians

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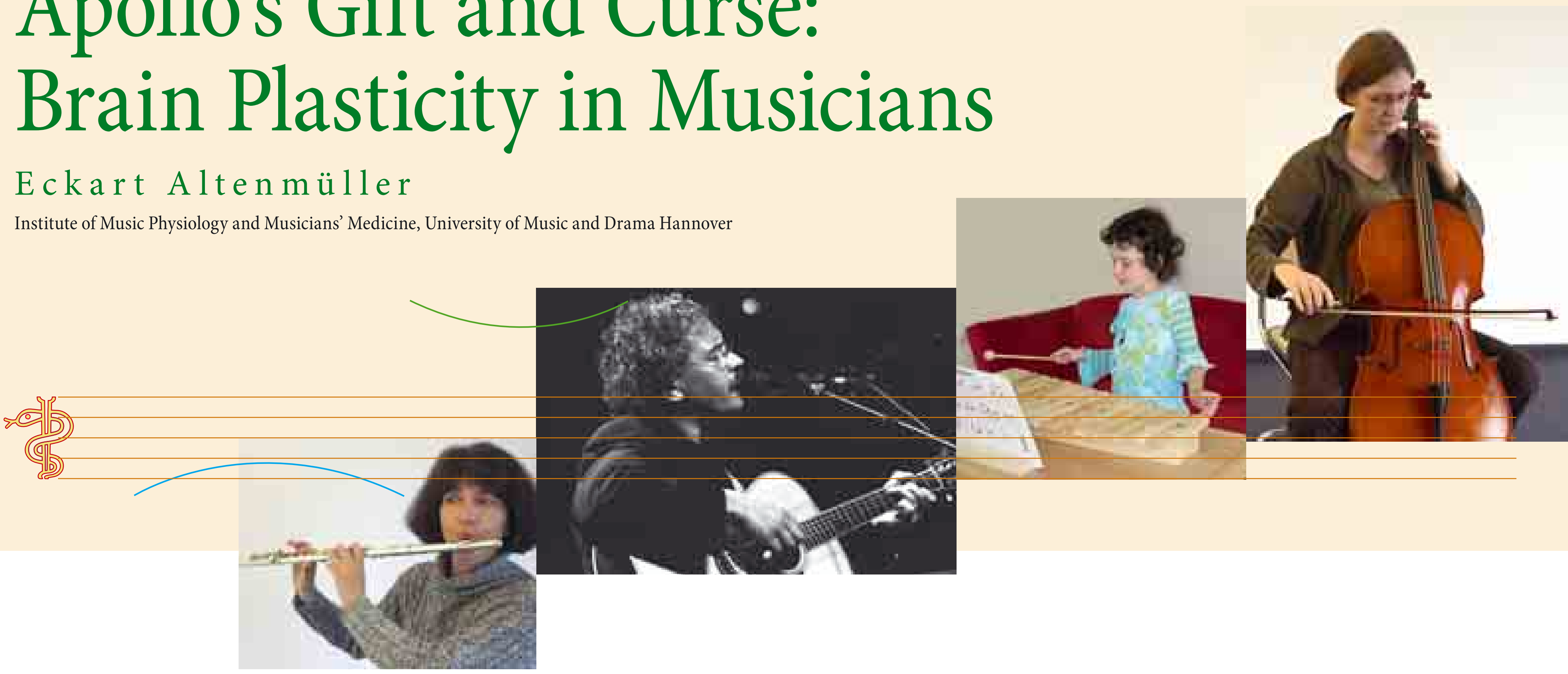

Apollo's Gift: Music Making As a Stimulus for Brain Plasticity

Performing music at a professional level is perhaps one of the most complex of human accomplishments. As a sensory stimulus, music is both exceedingly intricate and structured along several dimensions. Moreover, making music requires the integration of multimodal sensory and motor information together with precise monitoring of motor performance via auditory feedback. In the context of western classical music, musicians must reproduce highly controlled movements almost perfectly and with high reliability. These specialized sensory-motor skills require extensive training periods over many years, starting in early infancy and passing through stages of increasing physical and strategic complexity.

Sensory-motor skills in musicians are usually automated by many repetitions. Aural skills on the other hand are typically refined through a broad variety of listening experiences. Both types of skill, however, are not represented in isolated brain areas but depend on the multiple connections and interactions established during training within and between different regions of the brain. Musicians can learn new works and improve their skills over many years because the central nervous system (CNS) is able to adapt to changing environmental conditions and newly imposed tasks during its entire life span, a phenomenon that is referred to as plasticity.

In music, learning through experience and training is accompanied by remarkable brain adaptations, which are reflected not only in modifications of the brain's neuronal networks through enhanced neuronal connectivity but also in its overall gross anatomy. Music practice enhances myelination, gray matter growth and fiber formation of brain structures involved in the specific musical task [1].

There are two main reasons why researchers believe that these effects on brain plasticity are more pronounced in instrumental music performers than in those undertaking other skilled activities. First, musical training usually starts very early, sometimes before age six, when the adaptability of the CNS is highest. Second, musical activities are strongly linked to positive emotions, which are known to enhance plastic adaptations.

This review will focus on new insights into brain mechanisms involved in musical performance and practice. First, I will demonstrate changes in brain networks and structures accompanying musical achievements. I will then briefly comment on the neural foundations of training strategies such as mental and observational practice. After addressing the effect of music training on general cognitive abilities, I will conclude with a discussion of effects related to maladaptive changes of brain networks, resulting in movement disorders such as musician's dystonia.

Wiring the Brain: Music Making as a Sensory-Motor Integration Task

As mentioned above, performance-based music making relies primarily on a highly developed integration of auditory and motor abilities. In addition, feedback in the somatosensory system (that is, the receptors and processors related to e.g. touch and body position) constitutes another basis of high-level performance. Especially important here is the kinesthetic sense, which enables control and feedback of muscle and tendon tension as well as joint positions which allow continuous monitoring of finger, hand or lip position within the frameworks of body and instrument coordinates (e.g. the keyboard, the mouthpiece).

One special quality of musicianship therefore is the strong coupling of sensorimotor and auditory processing. Practicing an instrument involves assembling, storing and constantly improving complex sensorimotor programs through prolonged and repeated execution of motor patterns under controlled monitoring by the auditory system. Many professional pianists for example report that their fingers move more or less automatically when they are listening to piano music played by a colleague. A cross-sectional experiment undertaken with professional pianists revealed strong linkages between auditory and sensory-motor cortical regions developed over many years of practice. Using functional magnetic resonance imaging, subjects were asked to listen to simple piano tunes without moving their fingers or any other body part. Figure 1 shows the increased neuronal activation of professional pianists in comparison to nonmusicians. There is an impressive activation of the motor cortex, demonstrating subconscious or automated auditory-motor coactivation.

Furthermore, in a longitudinal study, it was possible to follow the formation of such neuronal multisensory connections during piano training by beginning pianists. Nonmusicians, who had never played an instrument before, were trained on a computer piano twice a week over a period of five weeks. They listened to short piano melodies of three-second duration played in a five-tone range, and were then required, after a brief pause, to replay the melodies as accurately as possible with their right hand. After 20 minutes of training, first signs of increased neuronal coupling between auditory and motor brain regions were observable. After five weeks, listening to piano tunes produced additional activity in the central and left sensorimotor regions. Playing on a mute (soundless) keyboard produced additional activity in the auditory regions of both temporal lobes [3]. This experiment impressively demonstrates how dynamically brain adaptations accompany these multiple sensorimotor learning processes.

Activation of motor corepresentations can occur in trained pianists not only by listening to piano tunes, but also by observing a pianist's finger movements on a video. The brain mechanisms of such learning through observation have been clarified in recent years. When monkeys observed the actions of other monkeys, for example grasping peanuts, exactly the same brain areas were active as if the observing animals were performing the observed action themselves. Additionally, a region in the parietal lobe of the observing monkeys was activated, which is believed to represent the knowledge that 'it is not

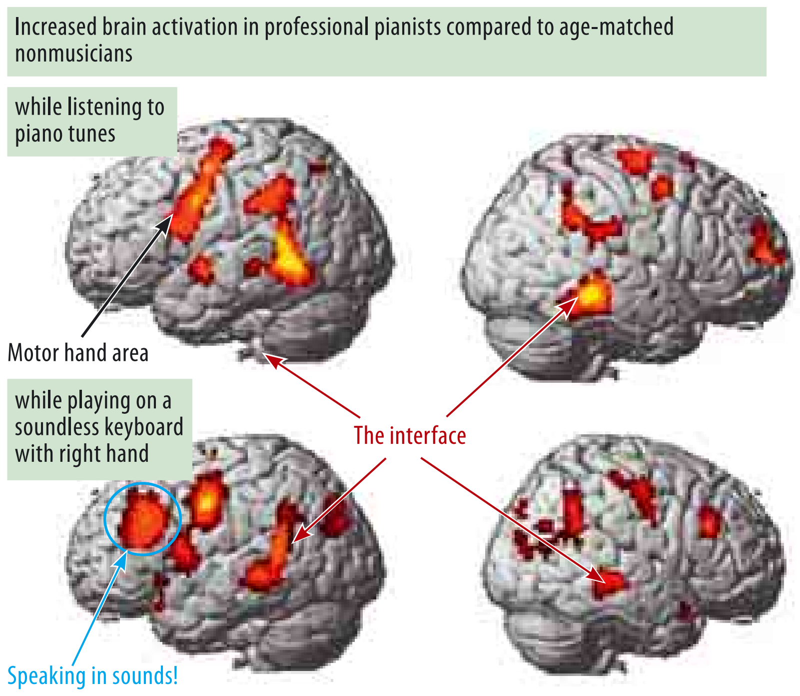

Fig. 1. Additional brain activity (yellow-red zones) in skilled pianists compared to nonpianists when listening to piano tunes without moving their fingers (upper row), or when moving their fingers on a mute keyboard (lower row). When listening, the primary hand area of the precentral area is active (black arrow), revealing an unconscious corepresentation of heard tunes as movement patterns. Furthermore, an auditory association area between the temporal and the parietal lobe lights up (red arrows). This region is also active when the pianists move their fingers on the mute keyboard, and thus seems to be an auditory-motor interface, translating the sounds into fingerings and vice versa. Moving the fingers on a mute keyboard additionally produces activity in Broca's area (blue arrow). This area, therefore, is not confined to language functions as has been traditionally believed but also contributes in a more general manner to complex movement patterns which code symbolic communication. It impressively demonstrates that music 'speaks' to our souls. [Figure modified from ref. 2.]

me who is performing the action.' Quite appropriately, this neuronal network has been termed a 'mirror neuron network.' When trained pianists are observing video sequences of a moving hand at the piano, the motor hand area in the primary motor cortex, and secondary auditory cortices in the temporal lobe and the cerebellum are activated, convincing evidence for such a mirror system in humans. What this means for musical practice is that careful demonstration at the instrument may enhance learning.

Practicing through listening and/or observation can be considered special cases of mental training. Narrowly defined, mental training is understood as the vivid imagination of movement sequences without physically performing them. As with the observation of actions, by and large when an action is imagined, the same brain regions are active as if the imagined action were actually being performed; that is, the primary motor cortex, the supplementary motor cortex and the cerebellum. In a study investigating mental training of finger movement sequences of different complexities, brain activation increased with the degree of difficulty of the imagined motor task. Furthermore, when continuing mental practice over a period of several days, the involved brain regions showed plastic adaptations. Although these adaptations were less dramatic than if the motor tasks had been practiced physically, mental training produced a clear improvement in task performance as assessed in finger-tapping tests.

Plasticity of Sensory Motor Systems: Musicians' Brains Are Different

During the past decade, brain imaging has provided important insights into the enormous capacity of the human brain to adapt to complex demands. Brain plasticity is best observed in complex tasks with high behavioral relevance for the individual, i.e. that cause strong emotional and motivational activation. Plastic changes are more pronounced in situations where the task or activity has been developed early in life and whose performance is intense. Obviously, the continued activities of accomplished musicians provide the ideal prerequisites for brain plasticity, and it is not astonishing that the most dramatic brain plasticity effects have been demonstrated in professional musicians [1].

Our understanding of the molecular and cellular mechanisms underlying these adaptations is far from complete. Brain plasticity may occur on different time axes. For example, the efficiency and size of synapses may be modified in a time window of seconds to minutes, while the growth of new synapses and dendrites may require hours to days. An increase in gray matter density, which mainly reflects an enlargement of neurons, needs at least several weeks. White matter density also increases in response to musical training. This effect is primarily due to an enlargement of myelin cells. Myelin cells, wrapped around the nerve fibers (axons), contribute to the velocity of the electrical impulses traveling along the nerve fiber tracts. Under conditions requiring rapid information transfer and high temporal precision, these myelin cells grow and nerve conduction velocity increases. Finally, brain regions involved in specific tasks may also be enlarged after long-term training due to the growth of structures supporting nerve function, for example, the blood vessels that are necessary for transport of oxygen and glucose to sustain neuronal activity.

Comparison of the brain anatomy of skilled musicians with that of nonmusicians shows that prolonged instrumental practice leads to an enlargement of the hand area in the motor cortex and to an increase in gray matter density corresponding to more and/or larger neurons [4]. These adaptations appear to be particularly prominent in all instrumentalists who have started to play prior to the age of ten and correlate positively with cumulative practice time. Furthermore, in professional musicians, the anatomical difference between the larger, dominant (mostly right) hand area and the smaller, nondominant (left) hand area is less pronounced than in nonmusicians. These results suggest that functional adaptation of the gross structure of the brain occurs during training at an early age.

The size of the corpus callosum also responds to such specialization. Professional pianists and violinists, and especially those who started to play prior to the age of seven, tend to have a larger anterior (front) portion of this structure [5]. Since this part of the corpus callosum contains fibers from the motor and supplementary motor areas, it seems plausible to assume that the high demands on coordination between the two hands and the rapid exchange of information may either stimulate nerve fiber growth – the myelination of nerve fibers that determines the velocity of nerve conduction – or prevent the physiological loss of nerve tissue during aging.

It is not only motor areas, however, that are subject to anatomical adaptation. With magnetoencephalography it is possible to monitor the number of nerve cells involved in the processing of auditory or somatosensory stimuli. Professional violinists have been shown to possess enlarged sensory areas corresponding to the index through to the small (second to fifth) fingers of the left hand [6], while their left thumb representation is no different from that of nonmusicians. Again, these effects are most pronounced in violinists who started their instrumental training prior to the age of ten.

In summary, when training starts at an early age (before about seven years), these plastic adaptations of the nervous system affect brain anatomy by enlarging the brain structures that are involved in different types of musical skill. When training starts later, it modifies brain organization by rewiring neuronal webs and involving adjacent nerve cells to contribute to the required tasks. These changes result in enlarged cortical representations of, for example, specific fingers or sounds within existing brain structures.

The Impact of Musical Training on General Cognitive Skills

It has long been assumed that an increase in brain connectivity or in gray matter density can improve general cognitive abilities. Typically, this is investigated with intervention studies assessing the effect of music lessons on performance in other cognitive domains. For example, in Montreal (Canada) between 1994 and 1997, Eugenia Costa-Giomi compared intelligence quotients (IQs) in children with and without piano lessons. Sixty-seven 9-year-old children from a rather poor social stratum were given weekly piano lessons for three years; the control group of 50 children had no piano lessons. At the beginning of the study all the children showed the same IQ for language, spatial and mathematical performance. After two years, the piano students were ahead in all three tested IQ domains; however, after three years, the children in the control group had caught up [7]. Similar results have been obtained in more recent studies. In an intervention study led by Schellenberg, 144 6-year-old children were given piano lessons, singing lessons, drama lessons or none of these for a period of 36 weeks. After these nine months, the IQ values for the children with piano and singing lessons were 3–3.5 higher than for the other children [8].

Such effects of music lessons on cognition are apparently not restricted to children. Bugos and colleagues [9] gave piano lessons for six months to 20 senior citizens aged between 60 and 85 years and compared their cognitive skills with those of 18 similar elderly people. After the piano lessons, the piano group showed significant improvements in memory performance, working memory, planning memory and strategy management.

Perhaps the most convincing transfer effects can be found in the domain known as 'emotional competence.' Music education, for example, improves the ability to decode affective states in spoken language.

Apollo's Curse: Focal Dystonia

There is a dark side to the increasing specialization and prolonged training of musicians, namely loss of control and degradation of skilled hand movements, a disorder referred to as musician's cramp or focal dystonia (Fig. 2). The first historical record, from 1830, appears in the diaries of the ambitious pianist and composer Robert Schumann [10]. As was probably the case for Schumann, prolonged practice and pain syndromes due to overuse can precipitate dystonia, which is developed by about 1% of professional musicians and in many cases ends their career. Subtle loss of control in fast passages, finger curling (Fig. 2), lack of precision in forked fingerings in woodwind players, irregularity of trills, fingers sticking on the keys, involuntary flexion of the bowing thumb in string instrument players and impairment of control of the embouchure in woodwind and brass players in certain registers are the various symptoms that can mark the beginning of the disorder. At this stage, most musicians believe that the reduced precision of their movements is due to a technical problem. As a consequence, they intensify their efforts, but this often only exacerbates the problem.

Males, classical musicians of a younger age and instrumentalists such as guitarists, pianists and woodwind players are among the most commonly affected by focal dystonia. The majority of patients are soloists and often have a perfectionist, control-type personality. About 20% of such patients report a history of chronic pain syndromes or overuse injury. Preventing these musicians from developing chronic overuse and tendinitis will most probably prevent them from developing focal dystonia [11]. However,

Fig. 2. Symptoms of dysfunctional plasticity: typical patterns of dystonic postures in a pianist, a violinist, a flautist and a trombone player. Most frequently, involuntary curling of fingers and compensatory extension of adjacent fingers is observed. In wind instrumentalists, dystonia involves sensory-motor control of the embouchure. Typically in dystonia, no pain or sensory symptoms are reported. Dystonia may afflict almost all groups of instrumentalists but is more frequently seen in the right hand of guitarists and pianists and in the left hand of violinists.

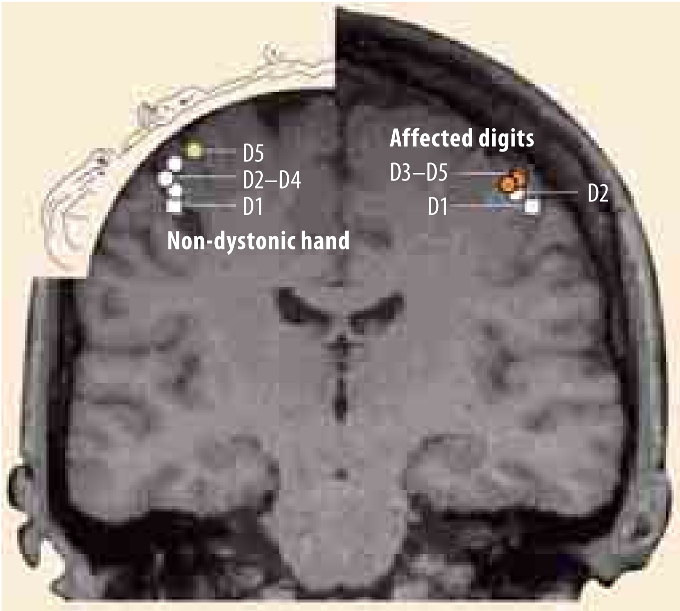

Fig. 3. Neuronal correlates of dysfunctional plasticity. Fusion of the somatosensory representation of single digits of the hand in a musician suffering from focal dystonia. The best-fitting dipoles explaining the evoked magnetic fields following sensory stimulation of single fingers are shown projected on the individual's magnetic resonance image. Whereas for the nonaffected hand, the typical homuncular organization (see inset) reveals a distance of about 2.5 cm between the sources for the thumb and the little finger (white square and yellow circle on the left), the somatosensory representations of the fingers on the dystonic side are blurred, resulting from a fusion of the neural networks which process incoming sensory stimuli from different fingers (red circles). [Modified with permission from refs 1 and 11.]

once focal dystonia is established, the cure of the pain syndrome will generally not eliminate the pathological movement pattern.

The etiology of focal hand dystonia is not completely understood, but is probably multifactorial. Most studies of focal dystonia reveal abnormalities in three main areas: (a) reduced inhibition in the motor system at cortical, subcortical and spinal levels, (b) reduced sensory perception and integration and (c) impaired sensory-motor integration. The latter changes are mainly believed to originate from dysfunctional brain plasticity. In patients with focal dystonia, there is growing evidence for abnormal cortical processing of sensory information as well as degraded representation of motor functions. A study with trained monkeys demonstrated that chronic overuse and repetitive strain injury in highly stereotyped movements can actively degrade the cortical representation of the somatosensory information that guides the fine motor hand movements in primates. A similar degradation of sensory feedback information and concurrent fusion of the digital representations in the somatosensory cortex was confirmed in a brain activation study conducted in musicians with focal dystonia.

Compared to healthy musicians, those with dystonia showed a fusion of the digital representations in the somatosensory cortex, reflected in the decreased distance between the representation of the index finger and the little finger (Fig. 3). Such a fusion and blurring of receptive fields of the digits may well result in a loss of control, since skilled motor actions are necessarily bound to intact somatosensory feedback input. Since these musicians had no history of chronic pain, additional factors such as a genetic predisposition appear to play an important role in the development of focal dystonia [12].

Unfortunately, there is no simple cure for the condition. Retraining may be successful in a minority of cases, but usually requires several years. Symptomatic treatment with temporary weakening of the cramping muscles by injecting botulinum toxin has proven helpful in other cases; however, since the injections need to be applied regularly every three to five months during the professional career, it presents no solution for young patients. Thus, the challenge is to prevent young musicians developing such a disorder. Reasonable practice schedules, economic technique, prevention of overuse and pain, mental practice, avoidance of exaggerated perfectionism, and psychological support with respect to self-confidence are the components of such a prevention program.

Conclusion

Musical performance is an excellent model to study the effects of neuroplasticity in the auditory and the sensory-motor domains. It seems to be one of the most powerful stimuli to drive plastic changes in the CNS. Future studies with professional musicians may allow us to differentiate the contributions of experience and training from those of genetic predisposition. Investigations of focal dystonia, meanwhile, may help to delineate the effects of dysfunctional plasticity due to overuse.

We are still, though, some way from the answers to one important question posed by the findings that have been discussed here. Music elicits strong emotional (and intellectual) responses. For humans, such responses are as essential to high-quality performance as to the reception of music and they are accompanied by strong activations of the limbic system – a network of brain centers at the inner border of the cortex – which is involved in reward, emotion and motivation. Much more research is required to show whether and how it is activity in areas of this network that mediates the strong and dynamic neuroplastic adaptations seen in performing musicians.

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About the author

Eckart Altenmüller (b. 1955) holds an MA in classical flute and an MD and PhD in neurology and neurophysiology. In 1994 he became Chair and Director of the Institute of Music Physiology and Musicians' Medicine, Hannover. His research focuses on the neurobiology of emotions and movement disorders in musicians as well as motor and sensory learning. Since 2005 he has been President of the German Society of Music Physiology and Musicians' Medicine and a member of the Göttingen Academy of Sciences.

The Cases of

Anne Blonstein

It must be every performing artist's nightmare – the actress forgetting her lines on the opening night, the dancer tripping over his own feet because he cannot remember the steps, the musician having a blackout while playing a composition she or he knows by heart … but that was precisely what happened to the American composer and pianist George Gershwin on the evening of 11 February 1937. While playing his *Concerto for Piano in F major* with the Los Angeles Philharmonic he stumbled over a couple of short passages. The audience did not notice, but in discussing the episode later, Gershwin mentioned that before the blackout he had smelled burning rubber. These were, as it turned out in retrospect, late symptoms of an undiagnosed brain tumor: five months later, one of America's most inventive and dynamic composers died after unsuccessful surgery at the age of 38.

A Rhapsodic Debut

George Gershwin was born in New York on 26 September 1898 into a family of Jewish Russian immigrants. He had an older brother, Ira, who later wrote the lyrics to most of Gershwin's songs. Early on Gershwin showed a talent for the piano and made his public debut on 21 March 1914, playing a tango he had composed himself. He left school at the age of 15 to work as a pianist.

For much of his life Gershwin was an extrovert, hard working, and a keen sportsman. He also fell deeply in love several times, but never married or had children. He composed his two most well-known works in his twenties, pieces in which he fused classical music with popular American forms such as ragtime, blues and jazz. *Rhapsody in Blue*, written in a few weeks in 1924 was an immediate success and made him famous overnight. It was followed in 1927 by *An American in Paris*, whose purpose Gershwin wrote was 'to portray the impressions of an American visitor in Paris as he strolls about the city, listens to the various street noises, and absorbs the French atmosphere.' *Porgy and Bess*, his first opera, written in 1935, was not well-received at first, but its compelling songs have ensured its place in the 20th-century opera repertoire. Some of these songs are the saddest and most anguished that Gershwin ever wrote, intimations of a sea change in Gershwin's character and mood.

An American in Pain

Despite his strong physique, as early as the 1920s, Gershwin was plagued by nausea and stomach complaints. For which no doctor was able to find a cause or cure. However, it was not until 1936 that Gershwin's friends and colleagues began to notice that this formerly extrovert man was growing increasingly melancholic. He became irritable and started complaining about matters he would previously have ignored. After the concert lapse, however, his private physician, Dr. Zilboorg, gave him a thorough medical examination but could find nothing wrong organically, and Gershwin was diagnosed as suffering from a psychosomatic disorder.

In the End Was Music: George Gershwin and Vissarion Shebalin

George Gershwin (1898–1937)

Vissarion Shebalin (1902 –1963)

Nevertheless, during the first half of 1937, Gershwin began experiencing headaches and dizzy spells, characterized by vertigo and an unpleasant spell. These spells occurred mostly in the morning or when he got nervous before playing a concert or a tennis match. He never lost consciousness. His doctor examined him regularly, but Gershwin still had no discernible neurological deficits, and the diagnosis was always psychogenic. Gershwin was working on his fourth motion picture, *The Goldwyn Follies*, and his symptoms were explained as 'a neurotic protest against the artificial world of Hollywood.'

By June, however, he had become noticeably indifferent, apathetic and somewhat slow-witted. His behavior had also become erratic – soon after receiving chocolate as a gift, he powdered it and started to rub it over his body as an ointment. He also complained of motor limitations in his right hand and motor incoordination. Gershwin was admitted to the 'Cedars of Lebanon' Hospital in Los Angeles for a thorough investigation. The results of all the tests – blood, X-rays, ECG, neurological – were normal, and Gershwin was discharged with the diagnosis of 'hysteria.'

Arrangements were now made for a nurse to be with him at all times and he received daily psychoanalytic treatment. All to no avail. His condition worsened. One evening, returning home from a party he sat down on the street with his feet in the gutter, put his head in his hands and complained bitterly that the splitting headache and the stench of burning rubber remained with him almost permanently and were driving him crazy.

He dropped his knife when he was eating. Water spilled out of the glass when he tried to drink. A rest cure in a private nursing home was recommended and this seemed to do some good. He complained less about his headaches and played the piano with enjoyment. George Gershwin played his beloved instrument for the last time on the morning of 9 July 1937. That afternoon he collapsed and lost consciousness. He was taken again to the 'Cedars of Lebanon' Hospital.

In a deep coma, Gershwin did not react to painful stimuli, had small and unequal pupils, and no voluntary movements. He presented with slight right hemiparesis, papilledema with retinal bleeding, and normal blood pressure without a stiff neck. His condition deteriorated and, on 10 July, the tentative diagnosis of a brain tumor was made. Dr. Harvey Cushing, a well-known neurosurgeon was called, and he recommended consultation with Dr. Walter Dandy of the Johns Hopkins Hospital in Baltimore, at the time the most distinguished practicing neurosurgeon in the US. The latter, however was on a cruise. A telegram was sent, but in the meantime, contact had also been made with another neurosurgeon in California, Dr. Howard Nafziger. Although he too was on vacation, he immediately flew in to Los Angeles from Lake Tahoe.

At 9 p.m. on 10 July, unable to establish the precise location of the suspected tumor, Rand and Nafziger trepanated Gershwin to undertake ventriculography. They found that both lateral ventricles were displaced far toward the left and, whereas the left lateral ventricle was basically normal in configuration, the right was greatly flattened and the right temporal horn was not filled at all. The intracranial pressure had been very high. There was clearly a tumor in the right temporal region.

Gershwin was taken into the operating room. During a procedure lasting 5 hours, Nafziger and Rand found a partially cystic malignant glioma and performed a partial resection. Gershwin, however, did not regain consciousness. His clinical situation worsened and he died on the morning of 11 July. Announcing his death on the radio, the commentator stated: 'The man who had more notes in his head than he could write down in a hundred years died suddenly today in Hollywood.'

It Ain't Necessarily So

Today the lesion would be called a multiform glioblastoma. These tumors start developing long before there are clinical manifestations of their existence, and the initial symptoms can easily be misdiagnosed. It has been speculated that Gershwin originally had a low-grade astrocytoma in the right temporal lobe that may have provoked the very early epigastric sensations and was certainly responsible for the temporal lobe seizures and olfactory auras. Only in the final phase did it undergo rapid malignant degeneration and turn into a fulminating glioblastoma multiforme.

Despite the gradual evolution of his disease, however, Gershwin's musical productivity until only months before his death remained prodigious. A highly trained artist, the preservation of his left hemisphere musical representation probably explains his preserved musical competence.

Words and Music

An even more dramatic illustration of the brain's spatial organization of its various processing functions is provided by the story of the Russian composer Vissarion Shebalin.

Shebalin was born in Omsk, Siberia, on 11 June 1902. He first studied at the musical conservatory in Omsk before moving on to the Moscow conservatory where he graduated in 1928 and was made a professor. He took the chair of the Department of Composition in 1941, and by 1942 was the conservatory's director.

Shebalin composed his first symphony as a student. A stream of compositions followed, including an opera performed at the Bolshoi Theater. He did not however escape the political purges of the post-war USSR, and in 1948, the level of his musical complexity attracted official rebuke for its so-called 'formalism.'

Music without Words

On 14 December 1953, Shebalin had his first stroke. This left him with hypesthesia (a diminished sensitivity to stimulation) and partial paralysis of his right hand and face. He also had severe language impairment. However, his condition improved over time and he was able to return to work.

During the next six years Shebalin, free of symptoms, continued to compose and perform his duties as the conservatory's director. However, on 9 October 1959 he had his second stroke, resulting in partial paralysis on the right side of his body.

In addition he now suffered from profound aphasia. He could no longer understand language nor could he speak, and even several weeks after the stroke, he could not articulate words successfully. He could not repeat phonemes, and his speech showed severe paraphasia, that is the substitution of one word for another and the unintelligible jumbling of words and sentences. For example, instead of 'okrepnuts' [to recover], he would say 'krepnost … okrepnost … krepnust … okrestno…,' all of which share a common root, but are meaningless or mean something else.

Two months after the stroke, he was able to speak some words and phrases, but in general the paraphasis persisted. His motor speech had partially recovered, but defects in the perception and understanding of speech remained. His comprehension of phrases was very limited.

Six months after the stroke and for the next 2 years Shebalin underwent neuropsychological tests and therapy. He was diagnosed with an acoustic (sensory) aphasia and defective kinesthetic organization of motor speech. A year after the stroke there were some improvements: his discrimination of speech sounds was better and his articulatory defects had diminished somewhat. He could name objects, but if three objects were presented to him simultaneously, the naming became confused again. His ability to read was preserved and, to a certain extent, he could still write.

Shebalin was clearly aware of what had happened to him, and tried to explain his defects to his physician A.R. Luria: 'The words … do I really hear them? But I am sure … not so clear … I can't grasp them … Sometimes – yes … But I can't grasp the meaning. I don't know what it is.' This defect was particularly obvious when the word was presented in the absence of the object in question. In such cases, he could not grasp the referential meaning of the word.

Shebalin's personality seemed unaffected by the severity of the stroke and despite the severe language impairments, he continued to work. With the assistance of his students he completed compositions he had begun before the stroke and he created many new ones whose quality does not differ significantly from his earlier pieces. Some of his new compositions were performed in his presence on 9 October 1962. His fellow composer Dmitri Shostakovich remarked that 'the 5th symphony of Shebalin is a brilliant work of elevated emotions, optimism and vitality. This symphony, composed during his illness, is the creation of a great teacher.'

Sadly, this creative activity was not to last. On 30 April 1963, Shebalin succumbed to a third stroke with a cardiac infarct. He died on 29 May 1963. The postmortem revealed massive damage in the temporal and inferior parietal regions, with a hemorrhagic cyst in the left temporoparietal region.

Despite his profound aphasia, Shebalin showed remarkable preservation of the receptive and expressive aspects of music, demonstrating the extent to which – in a professional musician at least – the cerebral processing of music and language can be separated.

(Continued from page 7)

… was ascribed to the rhythms and the modes employed in the music, but here, as throughout antiquity, there was much debate about whether it was music per se or the accompanying words which were actually responsible for the therapeutic effects.

As mentioned above, not only is there very little evidence in the medical and especially Hippocratic literature of the time for the application of music in the treatment of physical ills, there is often downright hostility. The Roman Quintus Sammonicus Serenus (died AD 212), author of a didactic medical poem, dismissed as an old wives' tale the notion that fever could be dispelled by modulated singing. Mainstream medicine of the time focused on diet, exercise, baths, drugs and surgery. Music if it was applied at all must perhaps be viewed as fringe medicine.

Following the decline of Greece and Rome, much of their philosophical and medical literature would have been lost had it not been translated into Arabic only to be (re)translated into Latin in the late Middle Ages after a veritable hiatus in the history of music therapy in most of Europe. In the Muslim world, however, music therapy had been appreciated and developed, both in the consulting room and the hospital, perhaps to a degree it was not again to enjoy until quite recently.

By the 13th century, Aristotle's work had been recovered for the west, and along with it his skepticism for the notion of the music of the spheres. Nevertheless, music was part of the quadrivium in medieval universities, taught after the trivium of grammar, logic and rhetoric. The four subjects of the quadrivium were arithmetic, geometry, astronomy and music, the latter considered as a study of 'the continuous in motion.' The focus though was more on harmonics and the study of proportions rather than music as actually practiced. And once again, in the medical writings of the time, discussions of music's power are common, but applications are few and have more to do with distraction and comfort than cure. In the instructions for conduct in a monastic infirmary near Canterbury, music is 'judged very useful for improving someone's condition,' and if a monk was very ill and his spirits needed raising, he was to be taken to the chapel where a stringed instrument should be 'sweetly played' to him. Music, however, was banned from the sickroom itself. With the dominance of humoral theories during the Middle Ages, far less distinction was made between preventive and therapeutic medicine, and the role of the physician was to maintain or restore the balance of the humors in the patient's body.

During the Renaissance, music therapy once again achieved a certain centrality in philosophical thought with the rebirth of Neoplatonism in the mid-15th century and the rise in the notion of natural magic. The activity of listening to or performing music was conceived as a remedy for particular diseases and as an aid to convalescence. The sicknesses concerned were usually 'passions of the mind,' prominent among which was, for example, lovesickness. Frustratingly, though, despite its advocacy, neither the physicians nor the music theorists who discuss music as a cure for erotic passion notate the music or indicate the recommended repertoire. They simply state that efficacious music should please or distract and should sympathize and harmonize with the sufferer's constitution. Either there was a tacit cultural assumption about what music was effective, or the suffering individual made choices based on his or her aesthetic tastes.

Although still somewhat controversial, one documented use of music as medicine, especially during the 16th and 17th centuries, comes from southern Italy (and other areas around the Mediterranean), and concerns tarantism, a state of melancholy and stupor that overcame victims of, allegedly, the bite of the tarantula spider. Music was the antidote. When played on string and percussion instruments to the sufferer, he or she would eventually start to move hands, feet and then the limbs. As the music continued, the victim began to dance, the body contorting in strange ways. The dancing, interrupted with breaks, could continue for up to six days, after which the victim should be cured. The music used for this healing ritual is said to be the origin of the southern Italian dance, the tarantella. However, since several people might be inflicted at the same time, skeptics claim that the condition and its cure were nothing more than a way to evade the Church's proscriptions against dancing.

During the early modern era, music was sometimes regarded in medical thought as a model for understanding the relationship between the body, mind and soul. To some extent these slightly occult notions spilled over into the 18th and even early 19th centuries. One dominant cultural feature of this period was Romanticism, which, after an early dalliance with the emerging scientific knowledge of its day, subsequently became much more ambivalent about its effects and value (as demonstrated, for example, by Mary Shelley's novel *Frankenstein*, published in 1818). Schopenhauer (1788–1860) went so far as to claim that because music was not a representational art, it actually presents or embodies the will. In the Romantic conception, music is powerful, but it is a double-edged power: it could cause as much as cure a disorder. Elvis Presley and the Beatles were not the first musicians to whip their young audiences into a frenzy: when playing piano recitals during the 1820s and 1830s, Franz Liszt (1811–1886) is reported to have inspired manic excitation or deep melancholy among the

Apollo, Greek god of music and healing.

(largely female) members of his audiences. His feminine admirers were so besotted that if he dropped his handkerchief, it was torn to pieces as souvenirs.

Romantic music though was tonic as well as toxic, and it perhaps found its most systematic application as a therapeutic in the mental asylums that are such a hallmark of the European 19th and early 20th century medical landscape. Even Liszt attempted some amateur music therapy, visiting hospitals in Paris and playing music for the patients, apparently with a beneficial effect. The diffusion of music as a treatment into the psychiatric institutions of the time may have had less to do with new musical or medical theories than with the commercialization of leisure and social life among the bourgeois members of society who made up a large part of the patient population in the asylums. Music therapy was especially promoted in German asylums, and one of the leaders in this area was the Illenau asylum in southern Germany. Here music was an integral part of asylum life and was clearly conceived as a restorative therapy. Illenau had its own choir, an in-house brass band and a full-time music instructor. In 1879 alone, it staged 140 musical events in which patients, doctors and visitors participated. Staff and patients not only performed, they also composed music.

The end of the 19th century also saw the birth of another philosophical approach – or spiritual philosophy as it terms itself – which took music very seriously and from early on developed methods for its therapeutic application: anthroposophy. According to its founder, Rudolf Steiner, humans and indeed all objects in the world have a spiritual tone which interacts with sound, and so musical tones can be used in therapeutic practice. Anthroposophy is well known for eurhythmy, a movement art that combines sound, speech and dance, but which is also applied to compensate for somatic and psychological imbalances, the aim being to strengthen the sick person's capacity for self-healing.

Even if music therapy was subordinate to the psychiatric objectives of the European asylums discussed above, the recognition and integration of music therapy into the psychiatric medical ethos are undeniable, an integration that is once more becoming evident in contemporary medical practice. But music has finally broken out of its psychiatric straightjacket. When a future historian comes to write about post-WWII music therapy, he or she may well start with the future's equivalent of PubMed where now, and doubtless increasingly so in the years to come, evidence-based demonstration of the therapeutic effectiveness of music in a broad range of medical fields is documented. No longer just an ideal, music therapy has become a life-enhancing practice.

Anne Blonstein

Further reading

Peregrine Horden (ed): Music as Medicine: The History of Music Therapy since Antiquity. Aldershot, Ashgate, 2000.

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