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# Music, Brain, and Body: A clinical and scientific overview

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Abstract: Listening to music can quickly engage or light up the whole brain. Both creating and listening to music is instinctual, and can influence physical, biochemical, and mental-emotional brain and body health in many ways through the nervous system, affecting hormones, stress, movement, and virtually all systems of the body. As such, music can serve as a valuable adjunct for people of all ages, including chiropractors and their patients. Music can have profound therapeutic actions in simple ways, from merely listening to songs to related basic biofeedback techniques. These and other topics are presented.

Indexing Terms: music; therapy; chiropractic; brain injury

## Introduction

Music is an inherent universal human art form, its cultural activity is organised logically in time and sensitivity, and in unique sounds and silences .(Garcia-Falgueras) The human application of music is instinctive, employing sound, vibration, and movement. (Mithen) The term '*music*' derives from the Greek *mousiké* [*tekhnē*] meaning the '*technique (or art) of the Muses*.' Music follows logical and natural mathematical patterns that can create trillions of unique melodies from a mere handful of single notes, and combine various sounds of harmony, rhythm, pitch, meter, timbre (sound colour), and other features with the potential to improve brain and body function.

> *… The most significant use of music as therapy is its use in people with brain injuries, including non-traumatic ones.'*

Music has been called a mnemonic device as it quickly cues or activates virtually all areas of the brain. (Tamminen) Functional magnetic resonance imaging clearly shows how well music lights up the whole brain. (Alluri) From the beginning of human existence, music has played an integral role by way of its effects on the nervous system, and therefore posture and gait, creativity, and behaviour, while playing a primary role in evolutionary and social success. (Schulkin)

Music can influence the physical, biochemical, and mental-emotional brain through many neurological and hormonal pathways to literally help grow the brain and expand the mind housed within. Studies show the brains of music-oriented people are larger and more functional than those who are not music-oriented. (Schulkin) This brain expansion is due to shifting states of consciousness, reducing excess stress hormones, enlisting the limbic and dopamine systems, encouraging muscle movement, and many other functions that could promote comfort and well-being, and which can be harnessed for specific therapies.

Thousands of years ago, Chinese Medicine described music as part of the Five Elements, denoting its music therapy qualities with the traditional Five Elements of musical tones corresponding to '*do, re, mi, so, la*' in the modern musical scale. (Zhang) The ancient Egyptians also emphasised music as a part of a healthy life. Early Greek philosophers Pythagoras, Aristotle, and Plato encouraged the healing and transformative power of music, while discovering the simple mathematics associated with it. (Thaut) Later, biologist Charles Darwin studied and wrote extensively about human music, with other scientists elaborating on it in recent years. (Honing; Schulkin) Darwin saw music as playing a key role in sexual selection, which, unlike natural selection was a means of impressing and choosing potential partners, contributing to reproductive success. In addition, Darwin, like other subsequent scholars, argued that musical vocalisations long preceded language and helped in its development. Music contributed to the formation of social bonds, and as song and dance evolved, it mimicked the neuro-chemical effects of social grooming, promoting endorphin release This musical role associated with human touch has important neurological, biological, and social consequences.

Today, the power of music is still almost always with us. Even during silence, our auditory cortex is active, most of us have music in our brains most of the time. The strong links between auditory and premotor cortex functioning also means mutual activation, even in the absence of one or the other sensation, so music can also activate movement even in people who are at rest. (Schulkin) Action permeates music and dopamine underlies the action of thought and the diverse cognitive systems that orchestrate the embodied musical expressions. Music is also strongly linked to cognitive actions, and to emotional responsivity and memory formation. An interesting effect of music on dopamine suggests that one function of this neurotransmitter is the prediction of a reward (even just hearing music) as dopamine neurons may fire more in anticipation of a rewarding event, than the event itself. Dopamine may be a key reason music is such a powerful therapy enabling people with Alzheimer's Disease and other forms of dementia to retrieve memories and engage with the world.

But does music always help us? While music has the potential to impact the brain and body significantly, it's not always so simple. For example, music strongly affects the autonomic nervous system (ANS); it can often raise the heart rate while lowering heart rate variability, yet some studies show this may not always occur. (Krabs) Herein lies an important scientific and clinical issue about music's influence on health: It's individual, and our hierarchical brain and body must be considered. If some significant stress is affecting the system just listening to music may not offset, reduce, or eliminate the stress or its effects. A common example is the consumption of junk food, in particular refined carbohydrate including sugar, which can impair blood sugar and adversely affect the ability for music to stimulate cerebral alpha waves, a shift of consciousness essential for music to produce optimal benefits. (Almerud; Krabs) (Unpublished data by the author demonstrated that impairment of cranial-innervated neck/head muscles can also reduce the ability to generate alpha waves.)

It is easy to see how the body's ability to adapt to stress through the hypothalamic-pituitary-adrenal axis can potentially be affected by music. As music has been shown to reduce excess levels of the stress hormone cortisol, and hinder its increase, it can help improve hormone balance, metabolism, neurological function, reduce blood pressure and inflammation, control pain and anxiety, and promote other healthy brain-body activities. (Tabrizi; Garcia-Falgueras) Individuals who selected their own music displayed a greater decrease in cortisol levels. In addition to and related to cortisol, other hormone levels respond to music: Dopamine and oxytocin may be elevated during music listening, also helping to reduce stress, with positive effects of other hormones, including testosterone, prolactin, nitric oxide, endorphins, and endocannabinoids playing a role in improving health. (Boso)

## Music Listening

We use our ears for listening and hear or sense music in our brains. It arrives there through a complex network, beginning with sound waves passing through the ear canals (we can also sense sound vibrations through bone). The ears filter the sound wave based on the music's frequency. (External sound is measured by decibels, dB, which is a logarithmic scale; loudness is not directly proportional to sound intensity, a sound at 20 dB is 10 times more intense than a sound at 10 dB.) Sound is collected and conducted by the external and middle ear, then transformed into electrical signals by cochlear mechanosensory hair cells. (Li) The outer hair cells enhance sound frequency and mechanical amplification while the inner hair cells are responsible for subsequent sound detection and transmission. These electrical signals are then transduced to the auditory cortex by spiral ganglion neurons in the canal of the cochlea. The signals ascend into the cochlear nuclei, superior olivary complex, and inferior colliculus for the perception of time and intensity, then move to the medial geniculate body, and finally, the sensation is integrated into and further processed by the auditory cortex (Both ascending and descending pathways to and from the cochlea and cerebral cortex form the complete auditory circuitry.)

An auditory hierarchy of sorts follows with pitch being the first component sensed. More complex sounds that are distinct from pitch follow, such as timbre and other specific sounds (including instrumental and vocal parts). The auditory stimulation continues into many other areas of the brain, including those not directly associated with the auditory system. These include emotional effects which enlist the amygdala, hippocampus, cingulate gyrus, and others of the multi-structured limbic system. In addition to the emotion of music, the limbic system is involved with memory storage and retrieval, and links the conscious with the subconscious, with autonomic function, and other actions. The excitation of the limbic system is associated with corresponding changes in neurotransmitters, such as dopamine, catecholamine, indolamine, the endorphins, neuron growth hormone, and others. (Meymandi) The brain's processing of rhythm has multiple overlapping structures including the cerebellum, which governs the important movement-related component of music.

Virtually all these and other brain areas that respond to the sounds of music can also potentially improve their functions. The ease of this is exemplified in the notion that even simple music listening can be quite effective for improving brain and body, a reason a solo singer-songwriter can capture a live audience's attention. This can make music therapy successful when addressing the many common functional problems encountered by individuals, and the reason it's used in the clinical management of those in intensive care and surgery, and in patients with neurodegenerative disorders, such as Alzheimer's dementia and Parkinson's disease, and psychiatric illnesses, including schizophrenia, depression, anxiety, and autism spectrum disorder. (Almerud; Boso; Meymandi; Garcia-Falgueras) This can be especially valuable in so-called alternative practices such as chiropractic. (Miller) (While music's therapeutic benefits are as old as humanity, modern medicine recently certified music therapy).

## Hearing loss

Dysfunction or pathology in any portion of the auditory circuitry can lead to hearing impairments or central auditory processing disorders, sometimes as functional problems in adults and children with attention, language and learning difficulties, such as dyslexia and ADHD. (Caras)

The cochlear mechanosensory hair cells are sensitive to ageing, acoustic trauma (loud noise), and overall health. Hypertension, heart disease, diabetes, iron deficiency, tobacco use, and over the counter and prescription drugs (such as aspirin and antibiotics) can contribute to sensorineural hearing loss. (Li) These auditory impairments are associated with cochlear hair cell loss, defined by an average pure-tone threshold detection exceeding 20 dB, and affect nearly a

half billion people worldwide. Nearly a third of those over age 65 have hearing loss, which is closely associated with cognitive decline and dementia independently in this population. Other lesions in the cochlea, auditory nerve, and other areas of the auditory pathway can induce hearing loss as well. Impacted earwax can cause conductive hearing loss, which is also a common problem. Overall health should be considered a preventative approach to hearing loss.

## Musical preferences

Humans have always made and consumed music and continue to develop and possess the underlying neurological structures associated with affective and intellectual complexity to ensure appreciation for, and creation of, novel music. (Schulkin) While the nervous system and genes are hard-wired for music, people have likes and dislikes based on social factors, memories, and other reasons, with song preferences narrower during youth and broadening with age. (Hurwitz)

Musical preference is strongly associated with emotion as it quickly evokes memories, especially of love and/or nostalgia, and can also produce physical reactions such as chills (and the so-called goosebumps), sweating, and tears. A certain song for a given individual and/or situation can induce the brain's reward centres, the dopamine system, associated with pain and pleasure; and can change or create a new mood that may range from happy to melancholy. As such, music can serve as an important real-time response, or therapy, to societal stressors, or to help meet emotional needs such as during the recent Covid-19 pandemic. (Fink) Likewise, violent songs can promote aggression and hostility, (Anderson) and the weaponised use of music for war is long known. (History) Music also has been employed in commercial marketing of unhealthy products, (Hafez) often called involuntary musical imagery or '*earworms*'. (Likkenan)

Music-evoked autobiographical memories and personal emotions are strongly associated with musical preference and can be specific or general, frequently involving people, places, and events. (Hurwitz) For this reason, a single audience can hear the same song and relate to it differently as all people have unique memories. Likewise, different people claim to know the meaning of a song's lyrics, yet it can be different than another individual's interpretation.

Two types of music top the list of songs to regularly use as both enjoyment and therapy:

- First are our favourite songs or musical pieces, which are powerful enough to change our physiology even if we've heard them hundreds or thousands of times. (Pagnini) The memories associated with these songs are neurological links to help improve brain and body health, with musical memories being quite resistant to cognitive dysfunction and ageing. The further these songs take you back in time the better; and
- Second is music that holds a surprise. Whether trained in music or not, when listening to music we know our brains appears to predict what to expect next; this is not the case with new songs. A great new song can present something musically and/or lyrically different, both as a surprise, and the unexpected. This is a great exercise for our frontal cortex, it challenges cognition, and can trigger more areas of the brain. And a great new song can still induce the dopamine system to release a burst of pleasure. You may not like all the new songs you hear. These new songs may or may not become favourites or get entrenched in our memories like the ones associated with our first love. Although, you never know. The power of surprise can be as potent as powerful memories. And we never run out of new songs.

## Brain injuries

The most significant use of music as therapy is its use in people with brain injuries, including non-traumatic ones. Impairment in any area of the brain can be referred to as a brain injury. In a real sense, we all have some type of brain injury due to physical, biochemical, and mental-emotional stress. As a general term that can encompass many different types of dysfunctions, brain injuries can be mild or severe, elusive or obvious, and many can be treatable with varying degrees of success. An important factor is that any improvement in function in one specific area of the brain can help other areas, too. This may be due to increasing circulation that brings in more oxygen and nutrients, or from a biofeedback effect that enlists or improves function in nearby areas first. The key concept is that brain plasticity allows for improved function in many circumstances, directly and indirectly. Some brain injuries and related therapies are described here.

## Amusia

We know why we listen to music, but another question is why some people don't listen to music or avoid it altogether. One answer is that they don't enjoy it because their brains are injured, and don't process music well. This is often associated with dysfunction in the frontal cortex and/or with frontotemporal connectivity. (Chen) The problem is called *amusia*, with two main classifications:

- Acquired amusia occurs because of brain damage following birth, and
- Congenital amusia results from a music-processing anomaly that occurs before and is present at birth.

Around 300 million people worldwide may have a form of *amusia*. These individuals typically have normal hearing and speech recognition, but difficulty recognising melodies and detecting pitch changes, and therefore cannot sing in key, one reason amusia is sometimes called '*tone deafness*'.

Signs and symptoms of amusia may be worse in some individuals compared to others, and some individuals don't follow the same patterns of dysfunction as others, leading this author to describe the condition as a spectrum disorder, inferring everyone is unique rather than all people with amusia are the same. Research shows that sometimes individuals without amusia can temporarily develop tonal dysfunction like someone with *amusia*. (Vuvan; Williamson) In other cases, two specific diagnoses can be combined: *amusia* can overlap with another brain injury called a*utism spectrum disorder*. While some autistic people occasionally have enhanced musical ability, most do not. (Sota) A common problem is the individual's inability to process musical, linguistic, and/or emotional pitch.

Some individuals on the *amusia spectrum* are unable to hear lyrics in songs, while some are unable to keep a beat to music. Some potential remedies for each of these problems are discussed below.

## Reading lyrics and listening

Neurologically, the binding of music with lyrics is relatively complex for the brain; it increases cognitive task and effort resulting in more brain activity. (Tamminen) Interestingly, the cerebellum, involved in motor activity, is enlisted in this process as well, connecting the motor and auditory systems to help bind and rehearse new lyrics to new music. Separately, listening to a new song enlists an extensive network of auditory and motor systems, along with basic memory processes and language comprehension areas, to help bind the music and lyrics. When reading the lyrics, the extensive visual centres are also turned on.

A specific type of brain injury is associated with the inability to hear lyrics within music. This is not uncommon and amenable to treatment. Most professionally recorded music with lyrics is mixed and edited by sound engineers so that most people can easily hear the lyrics being sung.

Below is the first of two specific and relatively easy at-home forms of music-related biofeedback. The first is a lyrical challenge and treatment developed by the author.

- Some people are not able to hear all, or any, words in songs, and/or misunderstand some of the words they hear. This is simple to assess just by listening to determine the ability to understand the lyrics. This problem may not seem significant, but it can indicate key brain areas are not as functional and/or not communicating with other areas. The remedy may be relatively simple, too: Find the lyrics of a song (most are online) and read them to yourself while listening to the song. Do this two or three times, then use a different song; continue over a period of a few days. After a week or so, test yourself by listening to one of these songs without seeing the lyrics, then listen to songs you've not seen the lyrics to (especially new songs). Usually, it's possible to begin hearing lyrics more clearly within two or three weeks. Continue the treatment as needed, although once the neurological connections are made and functions improve there is usually no need to continue treatment.

Another type of brain injury amenable to conservative treatment is a functional movement disorder associated with the cerebellum.

## Cerebellar dysfunction

Music and movement are very much related, and the cerebellum is a key area that coordinates this process. Without healthy coordination between brain and body, an individual may be unable to tap out a rhythm to a song, or otherwise keep a beat such as during dancing. If they play music, they may be unable to maintain even a reasonably consistent tempo. These individuals are sometimes seen as uncoordinated or clumsy and can have irregular gaits. Most are not athletic, but if they are physically active, injuries may be common. A metronome, or the free app for your phone, is needed for this assessment and treatment.

- Marching. Test your ability with a metronome set at a relatively slow 80 beats-per-minute and walk or march in place. Then try it while moving or walking around the house. Your feet should hit the floor exactly to the sound of the metronome, and your whole body should move in harmony. If that seems easy, increase the tempo to 90, then 100, or 120 bpm. Each time you go faster, keep marching to the beat. If this is not easy, the therapy is to spend time marching, starting slow and easy and work your way to faster paces. Use this therapy during walking, using stairs, or working around the house or office. The effectiveness is often evidenced after the first one to three days, it will become much easier to keep the beat at all paces. In more difficult cases it can take longer. For athletes, use this technique during training to help improve performance and reduce the risk of injury. Once you can march very effectively to different beats, you may not need to continue the therapy, although it's worth retesting every week or two before abandoning it. This is also an easy office test for use in patients.

In addition to listening to both favourite and new music, and performing the above biofeedback therapies as needed, playing music and/or singing can be a powerful way to enlist brain and body systems. This is best done in an enjoyable format, even short sessions, rather than through tedious and/or long practice periods.

## Conclusion

The human brain is naturally a musical one. Whole-body health benefits associated with music can occur across a wide range of neurological and hormonal domains influencing creativity,

learning, hearing, speech, language, memory, movement, stress adaptation, and many others that affect behaviour, social functioning, and quality of life. As such, enjoying music in our daily lives can serve as a source of joy, and a powerful therapy.

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Philip Maffetone is a graduate of National University of Health Science and writes and lectures on a wide range of health and fitness topics surrounding human performance. He has authored over 20 books and textbooks, publishes scientific research, and is a retired clinician and sports coach who implemented biofeedback, exercise physiology, physiotherapy, nutrition, and other approaches. Phil is also a professional singer-songwriter and music producer.

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