

3-28-2017

Music and the Mind: Music's Healing Powers

Carolyn S. Ticker

Cedarville University, cticker@cedarville.edu

[DigitalCommons@Cedarville](#) provides a publication platform for fully open access journals, which means that all articles are available on the Internet to all users immediately upon publication. However, the opinions and sentiments expressed by the authors of articles published in our journals do not necessarily indicate the endorsement or reflect the views of DigitalCommons@Cedarville, the Centennial Library, or Cedarville University and its employees. The authors are solely responsible for the content of their work. Please address questions to dc@cedarville.edu.

Recommended Citation

Ticker, Carolyn S. (2017) "Music and the Mind: Music's Healing Powers," *Musical Offerings*: Vol. 8 : No. 1 , Article 1.

DOI: 10.15385/jmo.2017.8.1

Available at: <http://digitalcommons.cedarville.edu/musicalofferings/vol8/iss1/1>

Music and the Mind: Music's Healing Powers

Browse the contents of [this issue](#) of *Musical Offerings*.

Abstract

Music makes you smarter: or at least that is what the "experts" are saying. CDs are sold of Mozart's Sonatas for babies, and parents are urged to give their children music lessons in the belief that music does something to our brains which in turn makes us more intelligent. But is this really true? Does music really affect the brain in the powerful way that scientists are suggesting, or is it hearsay? In this paper I investigate the effects of music on our brain's plasticity and cognition by looking at several different experimental studies. Specifically I will address how music affects brain plasticity, emotion, physical health and linguistic processing, and how these effects in turn make music a beneficial tool for therapy, particularly in patients with Traumatic-Brain Injury (TBI) and Autism-Spectrum Disorder.

Keywords

Music, mind, healing, brain, powers

Creative Commons License



This work is licensed under a [Creative Commons Attribution-Noncommercial-No Derivative Works 4.0 License](#).

Follow this and additional works at: <http://digitalcommons.cedarville.edu/musicalofferings>



Part of the [Fine Arts Commons](#), and the [Music Performance Commons](#)

Music and the Mind: Music's Healing Powers

Carolyn S. Ticker
Cedarville University

Have you ever heard the rumor that music makes you smarter? It is an adage that is often used to defend music's merits and is a statement that has drawn the attention of music researchers and scientists alike. Music, like language, is one of the universal aspects of human existence.¹ Regardless of nationality, age, or ethnicity, everyone has experienced music in some form or fashion, even if only in a primitive sense. Even from ancient times, as evidenced by Paleolithic cave drawings and the remains of rudimentary flutes, it seems that music-making is a human capability that is fundamental to human culture.² The Bible discusses music frequently and contains a book of Psalms, which is a collection of songs without musical scores. Music's existence in every culture points to its importance and influence. Therefore, if music has had such an important role in the lives of humans throughout all of history, is it not far-fetched to consider the potentially far-reaching impact that music has on our minds.

In the past, music has primarily been proclaimed as an enjoyable pastime, but its effects are much more far-reaching than simple elevation of a person's mood. Scientists are discovering more and more positive effects that music has on our cognition and physical health. As a result of this research, fields such as music therapy have been expanding and growing. Clinicians are using music in therapeutic settings to help those with brain damage or developmental disorders, especially in regard to children with Autism Spectrum Disorder and patients with traumatic brain injuries. Music is very powerful, and its effects on brain plasticity, cognition, emotion, and physical health have important and valuable repercussions for the field of healthcare.

¹ F. Clifford Rose, *Neurology of Music* (London: Imperial College Press, 2010), 3.

² Anthony Storr, *Music and the Mind* (New York: Free Press, 1992), 1.

In recent years especially, many researchers have conducted experiments in order to examine this connection between music and the brain. A study by Siamek Sheikhi specifically tested to see if musical stimulation during the fetal period affects brain neuroplasticity—the brain’s ability to change structurally or functionally depending on its environmental input. Using fetal rats as the test subjects, the experiment was conducted with two groups of pregnant rats: a control group and a music-exposed group. The music-exposed group was exposed to roughly ninety minutes of classical music per day, whereas the control group was not exposed to music at all. They discovered that there were significant morphological differences, such as more highly complex membranes and cytoplasmic organelles, in the fetal cells of the music-exposed rats versus the control group.³ In addition, the music-exposed rats had a higher cell density in the parietal cortex of the brain than did the control rats.⁴ However, although there were visible differences in the fetal cells themselves, there were no significant differences in the litter size or body weights of the respective groups of rats.⁵ Unfortunately the study did not examine any further effects of the music on the rats post-birth, but it does provide rudimentary evidence for changes in brain plasticity following exposure to music. Many companies have even taken advantage of the idea that music affects development by selling CDs of classical music specifically geared for parents to play for their infants.

Scientist Gottfried Schlaug has been very invested in research of brain plasticity. Schlaug and his colleague Catherine Wan write in their article entitled “Music Making as a Tool for Promoting Brain Plasticity across the Life Span” that “brain plasticity underlies normal development and maturation, skill learning and memory, recovery from injury, as well as the consequences of sensory deprivation or environmental enrichment.”⁶ Learning how to play an instrument, in particular, highlights the adaptability of the brain because it involves engaging multiple skill sets at once. For instance, a musician must learn to read musical notation, acquire the fine motor skills necessary to play the notes, memorize the

³ Siamek Sheikhi and Ehsan Saboory, “Neuroplasticity Changes of Rat Brain by Musical Stimuli during Fetal Period,” *Cell Journal* 16, no. 4 (2015): 450, <http://www.celljournal.org/journal/article/abstract/490>.

⁴ *Ibid.*, 452.

⁵ *Ibid.*, 451.

⁶ Catherine Y. Wan and Gottfried Schlaug, “Music Making as a Tool for Promoting Brain Plasticity across the Lifespan,” *The Neuroscientist* 16, no. 5 (2010): 566, doi:[10.1177/1073858410377805](https://doi.org/10.1177/1073858410377805).

music, and even improvise.⁷ A child who learns how to play the piano must learn how to play with both of their hands at the same time, which may raise their fine motor skills and ambidextrous coordination to a level that others may not possess. The coordination involved in playing an instrument is extremely difficult: “Musicians exert intensive and durable motor mechanisms required by the practice of their instrument, some specific to one hand or even to one or several fingers.”⁸ While many activities that are performed on a daily basis require the activation of several parts of the brain at once, music stretches even more of the brain than most other disciplines do.

One study conducted by Emma Moore and colleagues used Diffusion Tensor MRIs, a magnetic resonance imaging technique that measures the movement of water molecules in the brain’s white matter, to examine the connectivity of different brain areas.⁹ Their study found that there are actually structural differences between the white matter of musicians’ and non-musicians’ brains.¹⁰ A similar study by Robert Zatorre, referred to in Elena Mannes’s book entitled *The Power of Music*, found that “some areas of the cortex, the outer surface of the brain that contains ‘gray matter’ or the nerve cells called neurons, are thicker in people with musical training” and that the “motor and auditory regions also have more connections.”¹¹ Mannes also stated that professional musicians have 130 percent more gray matter in the auditory cortex than non-musicians, which is a startlingly large difference.¹² In the article “What Do Music Training and Musical Experience Teach Us about Brain Plasticity?,” authors Michael Habib and Mireille Besson point out that the corpus callosum, the band of nerve fibers that forms the bridge

⁷ Gottfried Schlaug et al., “Effects of Music Training on the Child’s Brain and Cognitive Development,” *Annals of The New York Academy of Sciences* 1060 (2006): 219–221, doi:[10.1196/annals.1360.015](https://doi.org/10.1196/annals.1360.015).

⁸ Michel Habib and Mireille Besson, “What Do Music Training and Musical Experience Teach Us about Brain Plasticity?” *Music Perception: An Interdisciplinary Journal* 26, no. 3 (2009): 279, doi:[10.1525/mp.2009.26.3.279](https://doi.org/10.1525/mp.2009.26.3.279).

⁹ Emma Moore et al., “Can Musical Training Influence Brain Connectivity? Evidence from Diffusion Tensor MRI,” *Brain Sciences* 4, no. 2 (2014): 408, doi:[10.3390/brainsci4020405](https://doi.org/10.3390/brainsci4020405).

¹⁰ *Ibid.*, 422.

¹¹ Elena Mannes, *The Power of Music: Pioneering Discoveries in the New Science of Song* (New York: Walker, 2011), 73.

¹² *Ibid.*

between the left and right hemispheres of the brain, is much larger in musicians than non-musicians, which could be due to the consistent transfer of sensory-motor information between the motor areas of both halves.¹³ Even for young children, studies have shown that the cortical motor system, auditory system, and corpus callosum are structurally different in those who have studied music than in those who have had no musical training.¹⁴

Music does not only engage the mind, but it also engages the body; listening to music can result in physiological changes like changes in heart rate, respiration, skin temperature, skin conductance, and hormone secretion.¹⁵ Because of this, music can be used as an effective therapy for both mental and physical conditions. Stroke victims and those with a traumatic brain injury (TBI) can especially benefit from music therapy. Those who experience a stroke or TBI often struggle with speech, visual, and motion deficits, and music therapy has been shown to help patients regain those functions and to have a more positive mood.¹⁶ Neurologic Music Therapy (NMT), particularly, can be a three-fold solution for these patients. NMT is the “therapeutic application of music to cognitive, sensory, and motor dysfunctions due to neurologic disease of the human nervous system,” and it seeks to address three major categories of functioning: sensorimotor, speech and language, and cognitive.¹⁷

The first major way in which music therapy is beneficial to a patient with TBI is aiding with sensorimotor function, or muscle movement. It is common for one who has suffered from a stroke to lose control of one side of the body, in essence rendering him or her paralyzed on only one side. One type of music therapy called Music-Movement Therapy (MMT) helps patients who are suffering from a TBI regain the use of

¹³ Habib and Besson, “Music Training and Musical Experience,” 279.

¹⁴ Lutz Jäncke, “Music Drives Brain Plasticity,” *F1000 Biology Reports* 1, no. 78 (2009): n.p., doi:[10.3410/B1-78](https://doi.org/10.3410/B1-78).

¹⁵ Teppo Särkämö and David Soto, “Music Listening after Stroke: Beneficial Effects and Potential Neural Mechanisms,” *Annals of the New York Academy of Sciences* 1252, no. 1 (2012): 267, doi:[10.1111/j.1749-6632.2011.06405.x](https://doi.org/10.1111/j.1749-6632.2011.06405.x).

¹⁶ *Ibid.*, 268.

¹⁷ Shantala Hegde, “Music-Based Cognitive Remediation Therapy for Patients with Traumatic Brain Injury,” *Frontiers in Neurology* 5, no. 34 (2014): n.p., doi:[10.3389/fneur.2014.00034](https://doi.org/10.3389/fneur.2014.00034).

motion in those areas of their body which were affected by the stroke.¹⁸ Scientist Eun-Mi Jun and colleagues wanted to study the effect of MMT on stroke patients' physical and emotional health and hypothesized that MMT would both increase a patient's mood and help them regain movement in the affected area of their body. Those who participated were separated into an experimental and a control group, and those who were in the experimental group participated in MMT. The researchers measured each patient's range of motion (ROM) in the shoulder, hip and elbow joints. They discovered that while the ROM measurements of those in the control group decreased or remained the same, the ROM measurements of patients who participated in MMT increased. The researchers also discovered that the mood states of those who did MMT were higher than those who did not.¹⁹ In addition to helping regain muscular movement, music therapy has also been shown to help stroke victims improve their gait and walk more steadily through the use of auditory rhythmic tools. In a study done by Spiros Prassas and his colleagues, patients' stride lengths and hip joint ROM became more symmetrical when they completed auditory rhythm exercises.²⁰ These studies reveal the positive effects of MMT on the joint motion of patients who suffered from partial paralysis due to stroke.

Because music affects brain plasticity, music also has a close connection with linguistic processing. Scientist Sebastian Jentschke, who was particularly interested in this relationship between music and language, tested children who were members of a choir versus non-members in two separate areas: music and language. Jentschke found that those who had musical training processed linguistic syntax more readily than those who were not musically trained.²¹ This finding lines up well with Brian Cates's discussion about the link between music and language in his article entitled "He Started the Whole World Singing a Song." He notes that "there is a significant overlap in how the brain processes music and

¹⁸ Eun-Mi Jun, Young Hwa Roh, and Mi Ja Kim, "The Effect of Music-Movement Therapy on Physical and Psychological States of Stroke Patients," *Journal of Clinical Nursing* 22, no. 1–2 (2013): 22–23, doi:[10.1111/j.1365-2702.2012.04243.x](https://doi.org/10.1111/j.1365-2702.2012.04243.x).

¹⁹ Jun, Roh, and Kim, "The Effect of Music-Movement Therapy," 26–27.

²⁰ Spiros Prassas et al., "Effect of Auditory Rhythmic Cuing on Gait Kinematic Parameters of Stroke Patients," *Gait & Posture* 6, no. 3 (1997): 221, doi:[10.1016/S0966-6362\(97\)00010-6](https://doi.org/10.1016/S0966-6362(97)00010-6).

²¹ Mannes, *The Power of Music*, 81–84.

language in that it activates the language areas of the brain such as Broca's area and Wernicke's area." The connection between music and language is very important, therefore, because music can be used as a beneficial method of treatment for patients with difficulties in either "the production of speech" or "the understanding of speech and writing."²²

Stroke patients who suffer damage to the Broca's area of the brain, which is largely responsible for speech production and is located in the left hemisphere, may experience aphasia, the lack of the ability to speak.²³ Although patients who have aphasia cannot speak words, researchers have noticed that they still have the ability to sing words.²⁴ The ability of a stroke patient to sing even when his or her speech capability is gone is largely a result of that fact that most melodic generation and music processing occurs on the right side of the brain, whereas speech production occurs on the left.²⁵ Melodic Intonation Therapy (MIT) in particular seeks to treat those who have aphasia and is defined as "a stepwise treatment that combines melody with words and phrases in an attempt to take advantage of the patient's ability to sing to facilitate speech output."²⁶ Brain scans show that Broca's area is much more active while the patient completes MIT versus when they complete only speech therapy. This suggests that the right hemisphere may play a role in assisting left hemisphere function when coupled together.²⁷ In some cases in which the damage to the left hemisphere is limited, the right hemisphere helps in speech production while the left hemisphere regains its speech production; however, in cases where the left hemisphere is almost completely damaged, the right hemisphere can learn to take control of the speech process entirely.²⁸ This hypothesis was tested and confirmed by one of Dr. Schlaug's studies, in which he found that each of the brain's hemispheres has a remarkable ability to compensate for the

²² Brian R. Cates, "He Started the Whole World Singing a Song," *Musical Offerings* 6, no. 1 (2015): 4, doi:[10.15385/jmo.2015.6.1.1](https://doi.org/10.15385/jmo.2015.6.1.1).

²³ Dwyer Conklyn et al., "The Effects of Modified Melodic Intonation Therapy on Nonfluent Aphasia: A Pilot Study," *Journal of Speech, Language, and Hearing Research* 55, no. 5 (2012): 1463, doi:[10.1044/1092-4388\(2012/11-0105\)](https://doi.org/10.1044/1092-4388(2012/11-0105)).

²⁴ Sala Horowitz, "The Healing Power of Music and Dance," *Alternative and Complementary Therapies* 19, no. 5 (2013): 265, doi:[10.1089/act.2013.19502](https://doi.org/10.1089/act.2013.19502).

²⁵ Conklyn et al., "Modified Melodic Intonation Therapy," 1464.

²⁶ *Ibid.*, 1463.

²⁷ *Ibid.*, 1464.

²⁸ *Ibid.*, 1469.

other side if in the event of an injury.²⁹ The ability of the brain to do this provides us with evidence of the brain's plasticity, especially soon after a stroke when the patient first begins to recover. In a study conducted by Dwyer Conklyn and colleagues, it was found that the group of patients who had participated in MIT achieved better speech output after one or two sessions than the control group did, lending evidence to the hypothesis that music therapy, especially if used soon after the occurrence of the stroke, can help patients regain speech.³⁰

Another aspect of stroke rehabilitation in which music therapy proves useful is regaining visual awareness. Many stroke patients experience visual impairment on the side of the brain opposite to the side in which the lesion occurred, which is referred to as unilateral neglect.³¹ Unilateral neglect causes perceptual dysfunction, because the patient fails to respond to stimuli on the side of the brain opposite to the side where the stroke occurred.³² Mei-Ching Chen and several colleagues conducted a study to test the effect of pleasant music on a stroke patient's visual awareness. According to Chen, prior research has shown that positive emotion can help increase visual awareness and that patients in other studies have responded better to emotional stimuli on the contralateral (opposite) side of the brain versus neutral stimuli.³³ Using this knowledge, they hypothesized that the use of pleasant music would help evoke positive emotion, which in turn could help stimulate the patients' visual awareness. After conducting the study, it was found that their hypothesis was indeed true; patients' visual awareness increased when the patient chose pleasant music to listen to while engaging in visual tasks.³⁴ Likewise, in a study conducted by Teppo Särkämö and David Soto, it was found that playing pleasant music for a stroke patient helped increase his or her positive affect and, thereby, his or her "attention resources available for visual processing."³⁵

²⁹ Horowitz, "The Healing Power," 265.

³⁰ Conklyn et al., "Modified Melodic Intonation Therapy," 1469.

³¹ Särkämö and Soto, "Music Listening after Stroke," 268.

³² Mei-Ching Chen et al., "Pleasant Music Improves Visual Attention in Patients with Unilateral Neglect after Stroke," *Brain Injury* 27, no. 1 (2013): 75, doi:[10.3109/02699052.2012.722255](https://doi.org/10.3109/02699052.2012.722255).

³³ *Ibid.*, 76.

³⁴ *Ibid.*, 79.

³⁵ Särkämö and Soto, "Music Listening after Stroke," 270.

Music therapy's impact is not just limited to patients with traumatic brain injuries. Music can assist a person in recalling information more easily, which is why information in the form of songs is used so frequently in education. Additionally, music can temporarily help enhance memory consolidation, attention, and reasoning.³⁶ For this reason, another primary use for music therapy is with children, especially with those who have autism.

Many practicing music therapists today work with autistic children, and their patients see great benefits like "increased appropriate social behaviors, improved attention to tasks, increased vocalizations, verbalizations, gestures, and vocabulary comprehension, increased communication and social skills, enhanced body awareness and coordination, improved self-care skills, and reduced anxiety."³⁷

However, in order to understand how music can have a beneficial effect on children who have an Autism Spectrum Disorder (ASD), one must first understand what autism is and how it manifests itself in those who have it. Autism is a neurodevelopmental disorder that is widely prevalent in America today, estimated to affect roughly one in every eighty-eight children.³⁸ In the article entitled "Music as a Therapeutic Intervention with Autism: A Systematic Review of the Literature," autism is described in detail:

Social deficits present themselves as an obvious and defining trait of individuals with autism. These individuals tend to have a deficit in interpersonal relations, abnormal developmental progress, problems with flexibility, and unsuitable emotional responses. Challenges in speech, eye contact, and communication make it difficult for individuals to persevere socially. . . . ASD is also characterized by repetitive behavior or interests including repetitive movements, ritualistic

³⁶ Särkämö and Soto, "Music Listening after Stroke," 267.

³⁷ Dawn De Vries et al., "Music as a Therapeutic Intervention with Autism: A Systematic Review of the Literature," *Therapeutic Recreation Journal* 49, no. 3 (2015): 221, <http://js.sagamorepub.com/trj/article/view/6085>.

³⁸ A. Blythe LaGasse, "Effects of a Music Therapy Group Intervention on Enhancing Social Skills in Children with Autism," *Journal of Music Therapy* 51, no. 3 (2014): 251, doi:[10.1093/jmt/thu012](https://doi.org/10.1093/jmt/thu012).

behaviors, strong focus on a topic or interest, and over or under-reactions to sensory simulation.³⁹

Children who have ASD often face social struggles that other children might not face. Although every child experiences hardships socially as they grow up and learn more about themselves, those with autism have more trouble making and keeping relationships. They may also face special difficulties in school, which is a place of both learning and social interaction. Children with ASD struggle with nonverbal communication and are often unable to share emotion and interests with others.⁴⁰ One reason that people with ASD struggle socially is because they often experience sensory overload, making it difficult for them to take in stimuli. Because social interactions involve perceiving different stimuli, integrating those signals, and then responding effectively, it is no wonder that children with ASD have difficulty in interacting and communicating with others.⁴¹

Music therapy can help children with ASD in several ways. A study by A. Blythe LaGasse of Colorado State University found that children with ASD who participated in a music therapy group exhibited greater improvement in social interaction than those who only partook in standard therapy.⁴² One way music therapy can do this is by decreasing anxiety. Children whose teachers played a song for them upon entering the classroom became much calmer and behaved better in the classroom after listening to the music.⁴³ Music therapy has also been proven to increase an autistic child's verbal communication skills. One form of music therapy, called Melodic-Based Communication Therapy (MBCT), uses a preprogrammed melody to elicit specific words while adding rhythms, usually clapping."⁴⁴ Another type, Improvisational Music Therapy (IMT), which is "the interactive use of live music for engaging clients to meet their therapeutic needs," allows children to engage

³⁹ De Vries et al., "Music as a Therapeutic Intervention," 221–222.

⁴⁰ De Vries et al., "Music as a Therapeutic Intervention," 221.

⁴¹ LaGasse, "Music Therapy Group Intervention," 252.

⁴² *Ibid.*, 271.

⁴³ De Vries et al., "Music as a Therapeutic Intervention," 232–233.

⁴⁴ *Ibid.*, 231.

actively in the music-making process.⁴⁵ Jinah Kim and colleagues conducted a study testing the effect of an IMT session versus a toy-play session on children with ASD. In the end, it was found that the children who took part in the IMT sessions exhibited greater joy in their facial expressions and a higher “emotional synchronicity” with their therapist.⁴⁶ Research has consistently shown that autistic children who partake in music therapy sessions will exhibit greater social interaction, a decrease in negative or disruptive behavior, decreased anxiety, joy, and greater verbal communication.

Because of the influence that music has on our brains, it is possible to use music in ways that greatly benefit those in need. It is obvious that music’s powerful effects on brain plasticity have profound implications for healthcare today. Those suffering from traumatic brain injuries can use music therapy to help them improve their mood and regain speech and movement. Likewise, music therapy also benefits children with autism by giving them tools to become more comfortable with social interaction and verbal communication. Music is powerful, and it should not be used lightly. When used in an uplifting and beneficial manner, even the most simple music can generate significant and profound results.

Bibliography

- Cates, Brian R. “He Started the Whole World Singing a Song.” *Musical Offerings* 6, no. 1 (2015): 1–33. doi:[10.15385/jmo.2015.6.1.1](https://doi.org/10.15385/jmo.2015.6.1.1).
- Chen, Mei-Ching, Pei-Leun Tsai, Yu-Ting Huang, and Keh-chung Lin. “Pleasant Music Improves Visual Attention in Patients with Unilateral Neglect after Stroke.” *Brain Injury* 27, no. 1 (2013): 75–82. doi:[10.3109/02699052.2012.722255](https://doi.org/10.3109/02699052.2012.722255).
- Conklyn, Dwyer, Eric Novak, Adrienne Boissy, Francois Bethoux, and Kamal Chemali. “The Effects of Modified Melodic Intonation Therapy on Nonfluent Aphasia: A Pilot Study.” *Journal of*

⁴⁵ Jinah Kim, Tony Wigram, and Christian Gold, “Emotional, Motivational and Interpersonal Responsiveness of Children with Autism in Improvisational Music Therapy,” *Autism* 13, no. 4 (2009): 390, doi:[10.1177/1362361309105660](https://doi.org/10.1177/1362361309105660).

⁴⁶ Kim, Wigram, and Gold, “Emotional, Motivational, and Interpersonal Responsiveness,” 402.

- Speech, Language, and Hearing Research* 55, no. 5 (2012): 1463–1471. doi:[10.1044/1092-4388\(2012/11-0105\)](https://doi.org/10.1044/1092-4388(2012/11-0105)).
- De Vries, Dawn, Teresa Beck, Bethany Stacey, Katelyn Winslow, and Kristyn Meines. “Music as a Therapeutic Intervention with Autism: A Systematic Review of the Literature.” *Therapeutic Recreation Journal* 49, no. 3 (2015): 220–237. <http://js.sagamorepub.com/trj/article/view/6085>.
- Habib, Michel, and Mireille Besson. “What Do Music Training and Musical Experience Teach Us about Brain Plasticity?” *Music Perception: An Interdisciplinary Journal* 26, no. 3 (2009): 279–285. doi:[10.1525/mp.2009.26.3.279](https://doi.org/10.1525/mp.2009.26.3.279).
- Hegde, Shantala. “Music-Based Cognitive Remediation Therapy for Patients with Traumatic Brain Injury.” *Frontiers in Neurology*, 5, no. 34 (2014): n.p. doi:[10.3389/fneur.2014.00034](https://doi.org/10.3389/fneur.2014.00034).
- Horowitz, Sala. “The Healing Power of Music and Dance.” *Alternative and Complementary Therapies* 19, no. 5 (2013): 265–269. doi:[10.1089/act.2013.19502](https://doi.org/10.1089/act.2013.19502).
- Jäncke, Lutz. “Music Drives Brain Plasticity.” *F1000 Biology Reports* 1, no. 78 (2009): n.p. doi:[10.3410/B1-78](https://doi.org/10.3410/B1-78).
- Jun, Eun-Mi, Young Hwa Roh, and Mi Ja Kim. “The Effect of Music-Movement Therapy on Physical and Psychological States of Stroke Patients.” *Journal of Clinical Nursing* 22, no. 1-2 (2013): 22–31. doi:[10.1111/j.1365-2702.2012.04243.x](https://doi.org/10.1111/j.1365-2702.2012.04243.x).
- Kim, Jinah, Tony Wigram, and Christian Gold. “Emotional, Motivational and Interpersonal Responsiveness of Children with Autism in Improvisational Music Therapy.” *Autism* 13, no. 4 (2009): 389–409. doi:[10.1177/1362361309105660](https://doi.org/10.1177/1362361309105660).
- LaGasse, A. Blythe. “Effects of a Music Therapy Group Intervention on Enhancing Social Skills in Children with Autism.” *Journal of Music Therapy* 51, no. 3 (2014): 250-275. doi:[10.1093/jmt/thu012](https://doi.org/10.1093/jmt/thu012).
- Mannes, Elena. *The Power of Music: Pioneering Discoveries in the New Science of Song*. New York: Walker, 2011.
- Moore, Emma, Rebecca S. Schaefer, Mark E. Bastin, Neil Roberts, and Katie Overy. “Can Musical Training Influence Brain Connectivity? Evidence from Diffusion Tensor MRI.” *Brain Sciences* 4, no. 2 (2014): 405–427. doi:[10.3390/brainsci4020405](https://doi.org/10.3390/brainsci4020405).
- Prassas, Spiros, Michael Thaut, Gerald McIntosh, and Ruth Rice. “Effect of Auditory Rhythmic Cuing on Gait Kinematic

- Parameters of Stroke Patients,” *Gait & Posture* 6, no. 3 (1997): 218–223. doi:[10.1016/S0966-6362\(97\)00010-6](https://doi.org/10.1016/S0966-6362(97)00010-6).
- Rose, F. Clifford, ed. *Neurology of Music*. London: Imperial College Press, 2010.
- Särkämö, Teppo, and David Soto. “Music Listening after Stroke: Beneficial Effects and Potential Neural Mechanisms.” *Annals of the New York Academy of Sciences* 1252 (2012): 266–281. doi:[10.1111/j.1749-6632.2011.06405.x](https://doi.org/10.1111/j.1749-6632.2011.06405.x).
- Schlaug, Gottfried, Andrea Norton, Katie Overy, and Ellen Winner. “Effects of Music Training on the Child’s Brain and Cognitive Development.” *Annals of the New York Academy of Sciences* 1060 (2005): 219–230. doi:[10.1196/annals.1360.015](https://doi.org/10.1196/annals.1360.015).
- Sheikhi, Siamak, and Ehsan Saboory. “Neuroplasticity Changes of Rat Brain by Musical Stimuli during Fetal Period.” *Cell Journal* 16, no. 4 (2015): 448–455. <http://www.celljournal.org/journal/article/abstract/490>.
- Storr, Anthony. *Music and the Mind*. New York: Free Press, 1992.
- Wan, Catherine Y., and Gottfried Schlaug. “Music Making as a Tool for Promoting Brain Plasticity across the Life Span.” *The Neuroscientist* 16, no. 5 (2010): 566–577. doi:[10.1177/1073858410377805](https://doi.org/10.1177/1073858410377805).