

Music as Medicine: The impact of healing harmonies



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The New Research Building
Harvard Medical School
77 Avenue Louis Pasteur
Boston, MA 02115



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Music as Medicine: The impact of healing harmonies

Moderator



Lisa Wong, MD

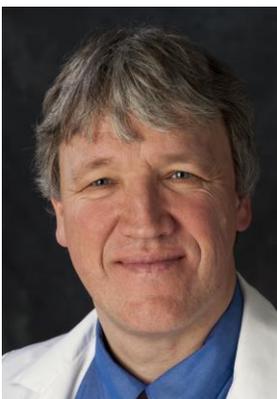
- Assistant Clinical Professor of Pediatrics, Harvard Medical School
- Pediatrician, Milton Pediatric Associates, Massachusetts General Hospital
- Co-founder of the Committee on Arts & Humanities at Harvard Medical School
- Co-Founder of the Boston Arts Consortium for Health
- Board member of the Massachusetts Cultural Council and the Conservatory Lab Charter School

Speakers



Nadine Gaab, PhD

- Associate Professor of Pediatrics, Harvard Medical School
- Department of Medicine, Division of Developmental Medicine, Boston Children's Hospital
- Principal Investigator, Gaab Lab Medicine Research



Gottfried Schlaug, MD, PhD

- Associate Professor of Neurology, Harvard Medical School
- Co-Director of the Stroke-Center, Chief of the Division of Stroke Recovery, and Director of the Music, Neuroimaging, and Stroke Recovery Laboratories, Beth Israel Deaconess Medical Center

About the Speakers:

Nadine Gaab, PhD

Nadine Gaab is an associate professor of pediatrics at Harvard Medical School and Boston Children's Hospital, and a member of the faculty at the Harvard Graduate School of Education. She received a PhD in psychology from the University of Zurich in Switzerland. She did postdoctoral training at Stanford University and MIT. Her current research within the Laboratories of Cognitive Neuroscience at Boston Children's Hospital focuses on auditory and language processing in the human brain and its applications for the development of typical and atypical language and literacy skills. The Gaab Lab utilizes structural and functional magnetic resonance imaging (fMRI) as well as behavioral measurement tools. The Gaab Lab is currently working on various topics such as the identification of possible pre-markers of developmental dyslexia in the pre-reading and infant brain, and the identification of the underlying neural mechanism of comorbidity of developmental dyslexia and attention deficit hyperactivity disorder.

Gottfried Schlaug, MD, PhD

Gottfried Schlaug is an associate professor of neurology at Harvard Medical School, and co-director of the Stroke-Center at Beth Israel Deaconess Medical Center. He also serves as chief of the Division of Stroke Recovery and Neurorestoration, and director of the Music, Neuroimaging, and Stroke Recovery Laboratories at Beth Israel. His main research interests are centered on ways to induce and detect in-vivo brain plasticity in patients recovering from a stroke or from developmental disorders affecting the auditory or auditory-motor systems, and in normal healthy subjects undergoing intense and long-time training of sensorimotor skills such as learning and playing a musical instrument. Schlaug has published over 250 peer-reviewed manuscripts and more than 20 book chapters together with his lab members and collaborators. His research work has been supported over the last years by grants from the NIH, NSF, CIMIT, Autism Speaks, and private foundations.

Lisa Wong, MD

Lisa Wong is a pediatrician, musician, and author dedicated to the healing arts of music and medicine. She is an assistant clinical professor of pediatrics at Harvard Medical School, and has worked with Milton Pediatric Associates since 1986. In April 2012, she published her first book, *Scales to Scalpels: Doctors who practice the healing arts of Music and Medicine*, in collaboration with writer Robert Viagas.

Wong plays violin and viola in the Longwood Symphony Orchestra (LSO) and served as its president from 1991-2012. LSO is a Boston-based orchestra made up primarily of medical musicians dedicated to healing the community through music, inspired by the work of Dr. Albert Schweitzer. The orchestra combines music, medicine and service and performs every concert to raise awareness and funds for medical nonprofits in the community.



ASK **DOCTOR K.**

Dr. Anthony Komaroff, Harvard Medical School | In Association with Harvard Health Publications

Is there a connection between music and health?

Posted January 18, 2014, 2:00 AM

Reviewed March 25, 2015

DEAR DOCTOR K:

I believe music helped my mother recover after her stroke. Is there a connection between music and health?

DEAR READER:

The ancient Greeks certainly thought so: They put one god, Apollo, in charge of both healing and music. Recent medical studies seem to confirm what the Greeks thought. Music seems to slow heart rate, lower blood pressure, and reduce levels of stress hormones. It can also provide some relief to heart attack and stroke victims and patients undergoing surgery.

How does music exert these benefits? Some research suggests that music may promote the brain's ability to make new connections between nerve cells.

Another idea is that it works its magic through its rhythms. Humans are rhythmic beings: Our heartbeat, breathing, and brain waves are all rhythmic. The human brain and nervous system are hard-wired to distinguish music from noise and to respond to rhythm and repetition, tones and tunes.

Not long ago I had a vivid example of that. I was late to attend a concert because of a noisy traffic jam with lots of honking. I parked the car and entered the theater. The concert had already started, and the music was louder by far than the sound of the traffic I had just left behind. But despite its volume, the sound of the music made me feel instantly at peace. I had left a world of disordered noise, and entered a world of ordered sound.

As you suspect may be true of your mother, there is some evidence that music can help with stroke recovery. One study enrolled 60 patients hospitalized for major strokes. All received standard stroke care. In addition, one-third of the patients listened to recorded music for at least one hour a day, another third listened to audiobooks, and the final group did not receive any auditory stimulation.

After three months, verbal memory improved by 60% in the music listeners, compared with 20% to 30% in the audiobook group and to the patients who did not receive auditory

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stimulation. In addition, the music listeners' ability to perform and control certain mental operations improved by 17%. The patients in the other two groups did not improve at all in this area.

Music therapy also is used to help patients with balance and coordination. A program designed to train older adults to walk and perform various movements in time to music helped improve their gait and balance when compared with their peers.

I introduced a friend with severe Parkinson's disease to a friend who was a singing teacher. I thought singing might help him cope with his disease. When my friend with Parkinson's disease would find himself "locked" and unable to walk or use his arms much, he would burst out singing a few notes of an aria—which unlocked his legs.

Finally, music can relieve stress. It can improve mood, even in people with depression. And it can lower heart rates, breathing rates, and oxygen demands in patients who have recently suffered a heart attack.

Music not only "has charms to soothe the savage breast." It also helps us to heal.

To learn more...

This information was prepared by the editors of the Harvard Health Publications division of Harvard Medical School. It is excerpted from our *Ask Dr. K* column, available at askdoctork.com.

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Harvard Women's Health Watch

Music can boost memory and mood

Dr. Anne Fabiny
Editor in Chief

March 2015

You may have seen the award-winning documentary film *Alive Inside*, which was released in 2014. It follows Dan Cohen, a social worker who is bringing music to people with dementia in nursing homes.

Cohen asked a documentary filmmaker to follow him around for three days to witness the astounding effect that music was having on the behavior, mood, and quality of life of patients who appeared to no longer have much of a connection to themselves and the world. The filmmaker was so moved and impressed that he followed Cohen for months and created this film.

Cohen's method is fairly simple. He asks a resident's family to list the songs or instrumental pieces the person once enjoyed. He then creates an individualized playlist on an MP3 player for the resident.

The music, which ranges from jazz to rock to classical, elicits surprising reactions. Some people, who had seemed unable to speak, proceed to sing and dance to the music, and others are able to recount when and where they had listened to that music. The music seems to open doors to the residents' memory vaults.

There is a growing body of evidence to explain why people in the film come back to life and begin to feel like their former selves when they listen to their playlists. Listening to and performing music reactivates areas of the brain associated with memory, reasoning, speech, emotion, and reward. Two recent studies—one in the United States and the other in Japan—found that music doesn't just help us retrieve stored memories, it also helps us lay down new ones. In both studies, healthy elderly people scored better on tests of memory and reasoning after they had completed several weekly classes in which they did moderate physical exercise to musical accompaniment.

Researchers at the music and neuroimaging laboratory at Harvard-affiliated Beth Israel Deaconess Medical Center have shown that singing lyrics can be especially helpful to people who are recovering from a stroke or brain injury that has damaged the left-brain region

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responsible for speech. Because singing ability originates in the undamaged right side of the brain, people can learn to speak their thoughts by singing them first and gradually dropping the melody. Former Representative Gabrielle Giffords used this technique to learn to speak well enough to testify before a Congressional committee two years after a gunshot wound to her brain damaged her ability to speak. Singing has also helped healthy people learn words and phrases faster.

To witness music therapy at work, go to the website of the Music and Memory Foundation, musicandmemory.org, and see what happens to one nursing home resident, Henry, as he listens to his music. You can also learn more about the movement that Dan Cohen has started and find out how you can get involved. And if you are caring for—or care about—someone with mild cognitive impairment or dementia, I guarantee it will inspire you to get an MP3 player and create a playlist for that person! It may also inspire you to make one for yourself, as well.

To learn more...

This information was prepared by the editors of the Harvard Health Publications division of Harvard Medical School. It is excerpted from the March 2015 issue of the *Harvard Women's Health Watch*, available at hvrd.me/JEuoj.

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Harvard Heart Letter

Using music to tune the heart

Music therapy, or just listening to music, can be good for the heart.

November 2009

Reviewed and updated March 25, 2015

Music can make you laugh or cry, rile you up or calm you down. Some say it's good for the soul. It just might be good for the heart, too. Make no mistake—daily doses of Mozart won't clean out your arteries or fix a faulty heart valve. But music can help ease your recovery from a cardiac procedure, get you back to normal after a heart attack or stroke, relieve stress, and maybe even lower your blood pressure a tad.

The sound of healing

Music and healing once went hand in hand. The Chinese character for medicine includes the character for music. In ancient Greece, music was used to ease stress, promote sleep, and soothe pain. Native Americans and Africans used singing and chanting as part of their healing rituals.

In Western medicine, the connection was gradually broken when the art of medicine gave way to the science of medicine. It's slowly being restored as music therapists demonstrate the value of music for treating people with everything from Alzheimer's disease to chronic pain and substance abuse problems. Since 1980, researchers have turned their attention to the effects of music on the cardiovascular system. Most have looked at single variables, such as changes in blood pressure, heart rate, or blood flow through arteries. A few have looked at more holistic effects. For example:

- At Massachusetts General Hospital, a nurse-led team found that people with heart disease who were confined to bed and who listened to music for 30 minutes had lower blood pressure, slower heart rates, and less distress than those who didn't listen to music.
- Another nurse-led team at the University of Wisconsin-Milwaukee found that heart attack survivors who listened to restful music in a quiet environment for just 20 minutes were less anxious about their health than those who rested in a quiet room without music.

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- At Abbott Northwestern Hospital in Minneapolis, men and women who listened to music soon after undergoing cardiac surgery were less anxious and reported having less pain than those who just rested quietly.
- At the University of Maryland Medical Center in Baltimore, researchers measured blood flow through the forearm (a stand-in for blood vessel health) as healthy volunteers listened to music or relaxation tapes. Blood flow increased significantly while the volunteers listened to music that evoked joy or to relaxation tapes, and decreased while they listened to music that provoked anxiety.
- In a study from Hong Kong, older volunteers who listened to relaxing music for 25 minutes a day for four weeks lowered their systolic pressure (the top number in a blood pressure reading) by 12 points and their diastolic pressure (the bottom number) by 5 points, while a control group that didn't listen to music had no change in blood pressure.

Not all the trials have been successful. Several found that music had little effect on physiological measures like heart rate or blood pressure, or on recovery from cardiac procedures.

Contradictory results shouldn't really be a surprise. One of the biggest hurdles to studying the effects of music on the heart is music itself. It isn't a single, repeatable "therapy" like a statin or stress-reducing breathing exercises. Soothing music, like Debussy's "Clair de lune" or George Winston's "Moon," have different effects on the heart and body than something more rousing, like "Seventy-Six Trombones" from *The Music Man*, Puccini's "Nessun dorma," or almost anything from the Red Hot Chili Peppers. Music is also highly personal—what you find soothing might sound to someone else like fingernails on a blackboard.

One thrust of current research in music therapy is to see if specific sounds or tempos affect the heart regardless of the listener's musical preferences. Finding a relaxing melody that slows the heart rate, reduces blood pressure, and improves blood flow for opera buffs and rock-and-roll fans alike would make it easier to offer music therapy.

Other mind-body methods

Music is just one of many techniques that have been promoted for healing the mind and body. Others include:

Transcendental meditation. Practicing the art of transcendental meditation can lower blood pressure, improve blood sugar and insulin levels, and ease stress. Other calming strategies, such as yoga or the relaxation response, can do the same.

Massage. After heart surgery, a simple massage decreased pain levels in a study at the Mayo Clinic. Whether massage affects the heart in other ways isn't well known, but it certainly does feel wonderful.

Tai chi. The combination of simple, flowing movements and deep breathing in tai chi offers a safe, rejuvenating

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form of exercise for people with heart failure.

Guided imagery. A program of directed thoughts and suggestions that help you imagine a relaxed, focused state can lower blood pressure and reduce other problems related to stress.

Prayer. Personal prayer can help evoke the relaxation response, which can reduce your own stress, while praying for a loved one or friend may provide emotional or spiritual support that reduces his or her stress.

Humor. Laughter may be good medicine for the heart and circulation. In a study at the University of Maryland, blood flow improved in volunteers who laughed at funny movie scenes.

Music in play

Today, music therapy is most commonly used for people undergoing a cardiac procedure and for those recovering from a heart attack or learning to cope with heart failure or other cardiovascular condition.

At the Mayo Clinic, for example, the Healing Enhancement Program offers music (along with massage and relaxation therapies) for people having heart surgery. "We encourage patients to listen to music before, during, and after surgery," says Susanne Cutshall, a clinical nurse specialist who heads the program. Studies there indicate that music helps ease pain and anxiety and blocks out distracting or disturbing hospital sounds.

Another important application of music therapy is helping people cope with a cardiovascular condition, whether they are recovering from a heart attack or living with angina, heart failure, or claudication. "Heart disease can be very stressful, and makes some people feel as though they have little control over their lives," says Suzanne Hanser, who chairs the music therapy department at the Berklee College of Music in Boston. Music therapy can alleviate stress, provide a pleasant coping strategy, and impart a feeling of control, she says.

In a trial conducted at a community hospital in Ohio, Hanser and her colleagues found that adding music therapy to standard cardiac rehabilitation led to better control of blood pressure, along with better general and mental health, than rehab alone. In her work with other cardiac patients, Hanser has seen improvements in sleep, reductions in stress, and the melting away of anxiety. As one patient wrote her, "I can't read notes or play a musical instrument, yet I love music. My body just seems to unwind as I listen."

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Help from nature

Do you have a favorite place? Perhaps you are drawn to a local park or pond, or enjoy strolling a beach to watch the sunset. Maybe you find solace in a church, museum, or library. Visiting "your place" several times a week is a good way to relax, forget your worries, boost vitality, and feel better about yourself, say Finnish researchers (*American Journal of Preventive Medicine*, May 2009). These restorative effects can be good for the heart, especially one that's under stress. Combine a visit to your favorite place with a long walk, and it's doubly good medicine.

Tuning in

There are several ways to let music into your heart. One is to work with a music therapist. If you can't find one through your cardiologist or medical center, try the American Music Therapy Association (musictherapy.org; 301-589-3300). Think of a music therapist as a guide, someone who can help you find the music that evokes from you the most relaxing responses as well as the most positive ones. He or she may help you become a more active listener, using music to help you ward off negative thoughts, release anxiety, and summon energy. A music therapist may also encourage you to make music with bells, drums, your voice, or other instruments.

If you will be needing an operation or procedure on your heart, check to see if your hospital has a music therapy program. They range from large ones like the Louis Armstrong Department of Music Therapy at Mount Sinai Beth Israel Hospital in New York to smaller programs like the one at Sacred Heart Hospital in Eau Claire, Wisconsin.

Do-it-yourself music therapy is another option. Find some music that makes you feel good. Pick some calm, relaxing pieces, as well as a few stimulating ones. If you are feeling stressed, sit and listen to the soothing music for 20 minutes or so. If you need a pick-me-up, play something energizing. Observe how the music makes you feel, and give in to those emotions. "The goal," says Hanser, "is to stop thinking of music as a treatment and make it an essential part of your everyday life."

To learn more...

This information was prepared by the editors of the Harvard Health Publications division of Harvard Medical School. It is excerpted from the November 2009 issue of the *Harvard Heart Letter*, available at hvr.d.me/KAVeJ.

Harvard Men's Health Watch

Music and health

July 2011
Reviewed March 25, 2015

Music is a fundamental attribute of the human species. Virtually all cultures, from the most primitive to the most advanced, make music. It's been true through history, and it's true throughout an individual's lifespan. In tune or not, we humans sing and hum; in time or not, we clap and sway; in step or not, we dance and bounce.

The human brain and nervous system are hard-wired to distinguish music from noise and to respond to rhythm and repetition, tones and tunes. Is this a biologic accident, or does it serve a purpose? It's not possible to say. Still, a varied group of studies suggests that music may enhance human health and performance.

Music and the brain

Like any sound, music arrives at the ear in the form of sound waves. The external ear collects sound waves, and the ear canal funnels them to the eardrum. As the waves strike the eardrum, they cause it to vibrate. The vibrations are relayed along the chain of tiny bones in the middle ear until they reach the third bone, the stapes, which connects to the cochlea.

The cochlea is a busy little world of its own. It is filled with fluid that surrounds some 10,000 to 15,000 tiny hair cells, or cilia. Vibrations of the stapes send fluid waves through the spiral-shaped cochlea. The fluid waves produce swaying movements of the hair cells. In turn, these cells release chemical neurotransmitters that activate the auditory nerve, sending miniature electric currents to the auditory cortex in the temporal lobe of the brain.

From there, things get even more complicated. Studies using MRI and positron emission tomography (PET) scans suggest that nerve networks in different parts of the brain bear primary responsibility for decoding and interpreting various properties of music. For example, a small area in the right temporal lobe is essential to perceive pitch, which forms the basis of melody (patterns of pitch over time), chords (several pitches that sound at the same time), and harmony (two or more melodies at the same time). Another nearby center is responsible for decoding timbre, the quality that allows the brain to distinguish between different instruments that are playing the same note. A different part of the brain, the cerebellum, processes rhythm, and the frontal lobes interpret the emotional content of music. And music that's powerful

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enough to be "spine-tingling" can light up the brain's "reward center," much like pleasurable stimuli ranging from alcohol to chocolate.

Although every healthy human brain can perform all the complex tasks needed to perceive music, musicians' brains are, so to speak, more finely attuned to these tasks. At the other end of the spectrum, patients with brain damage may display remarkable defects in musicality; the noted neurologist and writer Dr. Oliver Sacks discusses many fascinating varieties of amusia in his book *Musicophilia*.

The neurobiology of music is a highly specialized field. But music also has major effects on many aspects of health, ranging from memory and mood to cardiovascular function and athletic performance.

Music and the mind

The most highly publicized mental influence of music is the "Mozart effect." Struck by the observation that many musicians have unusual mathematical ability, researchers at the University of California, Irvine, investigated how listening to music affects cognitive function in general, and spatial-temporal reasoning in particular. In their first study, they administered standard IQ test questions to three groups of college students, comparing those who had spent 10 minutes listening to a Mozart piano sonata with a group that had been listening to a relaxation tape and one that had been waiting in silence. Mozart was the winner, consistently boosting test scores. Next, the investigators checked to see if the effect was specific to classical music or if any form of music would enhance mental performance. They compared Mozart's music with repetitive music by Philip Glass; again, Mozart seemed to help, improving spatial reasoning as measured by complex paper cutting and folding tasks and improving short-term memory as measured by a 16-item test.

How might music enhance cognitive performance? It's not clear, but the researchers speculated that listening to music helps organize the firing of nerve cells in the right half of the cerebral cortex, the part of the brain responsible for higher functions. According to this construct, music—or at least some forms of music—acts as an "exercise" that warms up selected brain cells, allowing them to process information more efficiently. It's an interesting theory, but before you rush out to stock up on recordings of Mozart's music, you should know that even in the original research, the "Mozart effect" was modest (8 to 9 IQ points) and temporary (15 minutes). And in reviewing 16 studies of Mozart's music and human cognitive function, a Harvard psychologist concluded that the effect was even smaller, amounting to no more than 2.1 IQ points. It's a sour note, but it's hardly a requiem for the theory that music may boost cognitive function. In fact, the divergent results should serve as a prelude to additional research. And even if listening to music turns out to have little long-term effect on cognition, a 2010 review reported that learning to play an instrument may enhance the brain's ability to master tasks involving language skills, memory, and attention.

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Music and stress

In every era of human history and in every society around the globe, music has allowed people to express their feelings and communicate with others. More than simply expressing emotions, music can alter them; as British dramatist William Congreve put it in 1697, "Music has charms to soothe a savage breast."

Few things are more stressful than illness and surgery. Can music reduce stress in these difficult circumstances? Several trials show it can.

A study from New York examined how music affects surgical patients. Forty cataract patients with an average age of 74 volunteered for the trial. Half were randomly assigned to receive ordinary care; the others got the same care but also listened to music of their choice through headphones before, during, and immediately after the operations. Before surgery, the patients in both groups had similar blood pressures; a week before the operations, the average was 129/82 millimeters of mercury (mm Hg). The average blood pressure in both groups rose to 159/92 just before surgery, and in both groups, the average heart rate jumped by 17 beats per minute. But the patients surrounded by silence continued to have high blood pressure throughout the operation, while the pressures of those who listened to music came down rapidly and stayed down into the recovery room, where the average reduction was an impressive 35 mm Hg systolic (the top number) and 24 mm Hg diastolic (the bottom number). The listeners also reported that they felt calmer and better during the operation. The ophthalmologic surgeons had no problems communicating with their patients over the sound of the music, but the researchers didn't ask the doctors if their patients' improved blood pressure readings made *them* more relaxed as they did their work. Earlier research, though, found that surgeons showed fewer signs of stress and demonstrated improved performance while listening to self-selected music.

A study of 80 patients undergoing urologic surgery under spinal anesthesia found that music can decrease the need for supplementary intravenous sedation. In this trial, patients were able to control the amount of sedative they received during their operation. Patients who were randomly assigned to listen to music needed less calming medication than those assigned to listen to white noise or to the chatter and clatter of the operating room itself.

In the cataract and urologic surgery studies, the patients were awake during their operations. But a study of 10 critically ill postoperative patients reported that music can reduce the stress response even when patients are not conscious. All the patients were receiving the powerful intravenous sedative propofol, so they could be maintained on breathing machines in the intensive care unit (ICU). Half the patients were randomly assigned to wear headphones that played slow movements from Mozart piano sonatas, while the other half wore headphones that did not play music. Nurses who didn't know which patients were hearing music reported that those who heard music required significantly less propofol to maintain deep sedation than those patients wearing silent headphones. The music recipients also had lower blood pressures

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and heart rates as well as lower blood levels of the stress hormone adrenaline and the inflammation-promoting cytokine interleukin-6.

Neither of the operating room studies specified the type of music used, while the ICU trial used slow classical music. An Italian study of 24 healthy volunteers, half of whom were proficient musicians, found that tempo is important. Slow or meditative music produced a relaxing effect; faster tempos produced arousal, but immediately after the upbeat music stopped, the subjects' heart rates and blood pressures came down to below their usual levels, indicating relaxation.

Musical medics

Is there a doctor in the house?

According to Arnold Steinhardt, a founding member and first violinist of the Guarneri String Quartet, chamber music audiences nearly always include many health care practitioners, "everything from podiatrists to psychiatrists, since there seems to be a mysterious and powerful underground railroad linking medicine and music. Perhaps music is an equally effective agent of healing, and doctors and musicians are part of a larger order serving the needs of mankind. Perhaps they recognize each other as brothers and sisters."

Many doctors love music, and many are fine musicians in their own right, playing everything from Dixieland to rock. There are classical orchestras composed entirely of doctors and medical students in Boston, New York, L.A., Philadelphia, and Houston, to say nothing of similar ensembles abroad. Several medical schools have started courses that use music to shape future physicians' listening skills.

Music and mood

Soothing jangled nerves is one thing; raising sagging spirits, another. Bright, cheerful music can make people of all ages feel happy, energetic, and alert, and music even has a role in lifting the mood of people with depressive illnesses. An authoritative review of research performed between 1994 and 1999 reported that in four trials, music therapy reduced symptoms of depression, while a fifth study found no benefit. A 2006 study of 60 adults with chronic pain found that music was able to reduce pain, depression, and disability. And a 2009 meta-analysis found that music-assisted relaxation can improve the quality of sleep in patients with sleep disorders.

Bach may never replace Prozac, but when it comes to depression, even a little help strikes a welcome chord.

Music and movement

Falling is a serious medical problem, particularly for people over 65; in fact, one of every three senior citizens suffers at least one fall during the course of a year. Can music help? A 2011 study says it can. The subjects were 134 men and women 65 and older who were at risk of falling but who were free of major neurologic and orthopedic problems that would limit walking. Half the

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volunteers were randomly assigned to a program that trained them to walk and perform various movements in time to music, while the other people continued their usual activities. At the end of six months, the "dancers" exhibited better gait and balance than their peers — and they also experienced 54% fewer falls. Similar programs of movement to music appear to improve the mobility of patients with Parkinson's disease.

Heart beats

You don't have to be a neurophysiologist to understand that music can affect the brain and at least a few of its many functions. And even if you're not a cardiologist, you may be interested to learn that music can also help the heart and circulation.

One way is by reducing stress. A study from Wisconsin evaluated 45 patients who had suffered heart attacks within the previous 72 hours. All the patients were still in an intensive care unit but were clinically stable. The subjects were randomly assigned to listen to classical music or simply continue with routine care. All were closely monitored during the 20-minute trial. Almost as soon as the music began, the patients who were listening showed a drop in their heart rates, breathing rates, and their hearts' oxygen demands. Music had no effect on their blood pressure; however, nearly all heart attack patients are given beta blockers and ACE inhibitors, both of which lower blood pressure on their own. The cardiovascular improvements linked to music lasted for at least an hour after the music stopped, and psychological testing also demonstrated lower levels of anxiety.

For heart attack victims, even short-term improvements are welcome. But music may also have long-lasting benefits. For a separate study, a team of scientists at nine American medical centers randomly assigned 748 patients who were scheduled for cardiac catheterization to receive standard care only, or standard care plus intercessory prayer (prayer on behalf of others); prayer plus music, imaging, and touch (MIT) therapy; or just MIT therapy.

The researchers tracked each patient for six months. During that time, there were no differences in the risk of major cardiac events; because these were the primary endpoints of the study, the investigators concluded that neither prayer nor MIT therapy was beneficial. But they also noted that while MIT therapy did not achieve any of the pre-selected goals, patients who received it experienced a clear decrease in anxiety and emotional distress—and they were also 65% less likely to die during the six-month study. Prayer was not associated with any potential benefit.

MIT therapy had three components: music, imaging, and touch. It's impossible to know if music was the key component, but that possibility would be in tune with other research.

Without offering final proof, these studies suggest that music may help the heart and circulation as well as the brain and mind. But how? Slowing the heart rate, lowering blood pressure, and reducing levels of stress hormones are likely explanations, and research presents

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another possibility. Scientists studied arterial function and blood flow in 10 healthy volunteers before, during, and after the subjects listened to various types of music, watched humorous videos, or listened to relaxation tapes. Joyful music produced a 26% increase in blood flow, a benefit similar to aerobic exercise or statin therapy and well ahead of laughter (19% increase) and relaxation (11%). But the power of music can work both ways; selections that triggered anxiety in the listeners produced a 6% decrease in blood flow. Men with teenaged children, take note.

Maladies of musicians

If there is a link between musicians and medics, perhaps musicians should be able to heal themselves. Many could use the help.

The most common problems stem from the repetitive motion of playing, often in combination with an awkward body position and the weight or pressure of the musical instrument. A Canadian study found that 39% to 47% of adult musicians suffer from overuse injuries; most involve the arms. The report suggests that musicians are as vulnerable to repetitive-use injury as newspaper workers (41% incidence) and that their risk is only slightly below that of assembly line food packers (56%). And since the survey included only classical musicians, it may underestimate the risk in the world of rock and pop. Even if music is good for the mind, it may not be so good for the wrist.

A particularly disabling ailment of highly trained musicians is focal dystonia, a movement disorder that may be caused by overuse of parts of the nervous system. Another hazard is hearing loss caused by prolonged exposure to loud music. Brass and wind players may develop skin rashes triggered by allergies to the metal in their instruments. And the list includes disorders ranging from fiddler's neck to Satchmo's syndrome (rupture of a muscle that encircles the mouth). One reassuring note: "cello scrotum," first reported in the *British Medical Journal* in 1974, was revealed to be a hoax 34 years later.

Concerts, too?

Most of the studies on music and health rely on individual listening, typically through headphones. That fits right in with the iPod generation's approach—but what about old-fashioned concert-going?

To find out, scientists in Sweden evaluated the habits of 12,982 people, recording their previous health, social networks, attendance at concerts and plays, education and income levels, and smoking and exercise patterns. As expected, smoking and previous illness predicted early death; exercise, higher education, and financial security predicted long life.

But there was also an unexpected finding: attendance at cultural events had a surprisingly powerful effect on mortality. In all, people who attended concerts and plays rarely or never were 1.57 times more likely to die during the study period than people who attended frequently. Occasional concertgoers were in between.

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The apparent protection conferred by cultural events was not explained by differences in income, social networks, or education. The investigators speculate that music may stimulate specific regions of the brain, causing favorable changes in hormone levels or immune function. Or perhaps concertgoers have their own version of a religious experience as they take in what Shakespeare called "music from the spheres."

It's only one study, and it should be confirmed before concert tickets take their place in the medicine cabinet. Even now, however, people who like to go to cultural events may get a little extra pleasure from the hope that something enjoyable may actually be healthful.

Music and muscles

Although iPods are perfectly capable of playing relaxing, stress-relieving, blood pressure–lowering classical music, they are more often used to blast up-tempo pop music, especially during workouts. Many athletes are hooked on their music—but does their performance actually benefit?

Perhaps. A British study compared the way rock, dance, inspirational music, and no music influenced the performance of runners. Many of the athletes thought the music was helpful, but it did not appear to increase their endurance. On the other hand, another investigation from the U.K. found that music increased treadmill-walking endurance. Israeli investigators reported that music boosted peak anaerobic power on a bike ergometer, but the benefit was very brief. American research found that music improved weight lifting, but a British trial reported that while energizing music boosted strength, relaxing music had the opposite effect.

The science of art

Biological explanations and clinical observations may not do full justice to the effect music has on man and his world. Fortunately, poets and philosophers can fill in the gaps.

Doctors tell us that social isolation is a cardiac risk factor, and Robert Browning wrote that "He who hears music feels his solitude peopled all at once." Psychologists tell us that expressing emotions is healthful, and Tolstoy explained that "Music is the shorthand of emotion." Clinicians teach that human warmth can blunt many woes, and Shakespeare proclaimed, "If music be the food of love, play on." And in the days when Apollo reigned, Plato explained that "Music is a moral law. It gives soul to the universe, wings to the imagination, and charm and gaiety to life and to everything else."

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To learn more...

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Harvard Mental Health Letter

Why songs get "stuck" in people's heads

May 2010
Reviewed March 25, 2015

Most people have experienced this phenomenon at one point or another: a mental replaying of a catchy tune, seemingly for no reason. The tunes that get stuck in people's heads are often advertising jingles, television theme songs, pop songs, and children's songs.

In scientific literature and in the lay press, the phenomenon goes by many names: sticky music, stuck songs, involuntary musical imagery, cognitive itch, mental concert, and earworm.

Studies involving functional MRI have revealed that people "hear" internal melodies in much the same way as they hear music from a real orchestra. In both cases, the auditory cortex—the part of the brain that processes sounds—becomes active. When the music is playing only inside someone's head, however, only part of the auditory cortex is activated, and it is likely that other parts of the brain—such as those involved in memory—also contribute.

Investigators in England set out to document how common the stuck song phenomenon is, and how people deal with it. The researchers approached people in community settings, such as a railway station and a public garden, and asked them to fill out a questionnaire about the phenomenon. All of the 103 respondents indicated they had experienced a stuck song at one point or another, and listed 159 different songs they could remember.

In a separate study, the same investigators asked 25 people to keep "stuck song" diaries for four weeks. Participants reported a total of 269 episodes (involving 199 songs), averaging a little more than one per week per person.

For the most part, the internal music didn't bother people. Some simply ignored it or went to sleep. Others silenced an internal melody by listening to real music—or by thinking about another tune. Still others simply listened to and tried to enjoy the internal music until it played out.

Harvard Health Letter

Sing along for health

March 2007
Reviewed March 25, 2015

Their mouths curve into O's as if in collective astonishment. Sometimes they sway. Other times, they lean toward each other, gathering themselves for that climactic note.

Whether in a barbershop quartet, an a cappella group, a gospel choir, or a community chorus, people who sing together often seem utterly happy and engaged.

And it may be true. Scientists have researched the effects of group singing, and the results show benefits for mood, stress levels, and even the immune system.

Researchers in Germany used questionnaires and before-and-after saliva samples to compare the effects of singing choral music with just listening to it. They found that singing buoyed mood and boosted the immune system activity. Just listening to choral music dampened spirits, although it did decrease the levels of cortisol, a stress hormone.

Singing may also offer benefits not unlike those of deep breathing exercises, which are recommended as a way to promote the stress-relieving "relaxation response." It requires similar deep, controlled breathing and focuses the person's attention on the lungs, diaphragm, and abdominal muscles.

Many studies have shown that people with various kinds of speech problems can often sing words that they have difficulty speaking. In 2006, University of Montreal psychologists reported that singing, per se, didn't help eight people with speech difficulties caused by damage to the left side of their brains. But singing in unison with a recording did help. The researchers said the results suggest that choral singing might be good therapy for some speech disorders.

The sing-along effect may not be limited to members of the choir. In his popular book *Bowling Alone*, Harvard's Kennedy School of Government professor Robert Putnam identified group song as a form of civic engagement that could lead to other kinds of involvement, such as volunteer work or political activism. On his website, www.bettertogether.org, Putnam includes singing in a choir on his list of ways to build "social capital"—the social networks, trust between individuals, and so on that make people happier and probably healthier, too.

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Diet and exercise—they dominate health advice. But perhaps it's time we started giving other activities—like choral singing—their due. We agree with Garrison Keillor: "To sing like this, in the company of other souls, and to make those consonants slip out so easily and in unison, and to make those chords so rich that they bring tears to your eyes. This is transcendence." And it may be good for your health, too.

To learn more...

This information was prepared by the editors of the Harvard Health Publications division of Harvard Medical School. It is excerpted from the March 2007 issue of the *Harvard Health Letter*, available at hvrld.me/Jwy02.

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Harvard Mental Health Letter

Music therapy may help depression

May 2008
Reviewed March 25, 2015

A review by the international Cochrane Collaboration concluded that music therapy may help some people with depression to alleviate symptoms and remain healthy. In four of the five studies the reviewers included in their analysis, people who participated in some type of music therapy reported a greater reduction of depressive symptoms than people who received other types of psychotherapy.

Because there are many types of music therapy available, the reviewers only examined those studies that involved music therapy carried out within a structured therapeutic framework that involved some type of musical interaction with a therapist or other patients. Mood symptoms were assessed through standardized instruments, such as the Beck Depression Inventory.

Duration of therapy varied from six to 10 weeks, and the type of interventions varied. For example, some included guided imagery along with the music, while others encouraged patients to listen to music and then discuss it. Most enrolled adolescents or older adults.

However, because all of the studies were small, involving 19 to 68 participants, the reviewers cautioned that they are not yet ready to conclude that music therapy is an effective treatment for people with depression. Even so, it may be worth considering as an adjunct to other treatments.

Commentary

The pleasure of improvising

Dr. Michael C. Miller

August 2012
Reviewed March 25, 2015

As an amateur musician, I was pleased to come across an article that brought together two of my favorite topics: music and the brain. Two scientists in Baltimore devised a clever way to discover what happens in the brain when a person improvises.

Improvisation in music involves playing novel melodies, harmonies, and rhythms, but staying roughly within the framework of the written music. It blends a high level of skill with spontaneity.

This special blend is not seen only in music. In fact, you don't have to be any kind of artist at all. Improvisation is just as much a part of cooking a stew or tinkering with a motorcycle.

On an everyday level, improvising is the difference between approaching work or play creatively and going through the motions. And it probably makes work and play more fun.

This study also suggests why improvising feels so good. Of course, anyone who has devoted hundreds if not thousands of hours of practice in order to master a skill will feel proud. And nothing beats the self-esteem that comes from playing well — whether you're playing the piano or playing basketball.

But as this study suggests, improvisation may provide a different sort of pleasure. Accomplished musicians and athletes (not to mention anyone who has invested time and energy in learning a trade or profession) cherish a reward of mastery—a state of mind of being in a "zone." It's what the psychologist Mihály Csíkszentmihályi has called "flow." Some people describe this state as one where the performer stops thinking about the performance and simply acts.

The biology of improvising

Dr. Charles Limb and Dr. Allen Braun of the National Institutes of Health conducted the study. Dr. Limb, who is an ear, nose and throat specialist, also plays jazz saxophone and is on the faculty of the Peabody Institute, the music conservatory at The Johns Hopkins University.

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Limb and Braun persuaded six professional jazz pianists to play a keyboard while they were inside a brain-scanning MRI machine. The pianists played a C-major scale. The scale is made up of only the white keys on the keyboard and is very simple for a trained pianist to play. The pianists also played a more complex original jazz composition that they had been given to memorize several days earlier.

The authors then asked the pianists to improvise on the scale and the composition. The researchers were particularly interested to see how the patterns of brain activity while playing rehearsed music compared to the patterns that appeared as musicians improvised.

Indeed, the scientists saw a clear difference between the two types of playing.

During improvisation, the medial prefrontal cortex (MPFC), which sits in the most forward part of the brain, became very active. Neuroscientists believe that the MPFC pulls together information that people use to achieve complex goals. In particular, these complex goals are the ones we tend to cherish because they are closely tied to our hopes and aspirations.

At the same time, the sides of the prefrontal cortex (PFC) were relatively quiet. This part of the PFC is more active when people are conforming to rules (as opposed to expressing themselves freely). It monitors and inhibits inappropriate behavior. It also tends to become more active (and therefore lights up on MRI scans) during problem solving and conscious planning.

Why improvising feels good

So you feel good when you improvise, in part, because you have turned on that part of your brain that is most closely aligned with your aspirations. At the same time, you are quieting neural centers that would otherwise hold you back. But there's more. The amygdala and hippocampus, structures in the brain that register emotions, especially anxiety, are also relatively quiet.

During improvisation, then, the brain stops being a slave to anxiety and rule-based inhibitions. Instead it is helping itself (that is, you) pursue cherished aims.

It is not so easy to find proficient jazz pianists eager to climb into an MRI scanner. That's why the number of subjects was too small for the study to be definitive. But the study design was clever enough—and the images clear enough—to paint a virtual picture of what the brain looks like when a person is being most inventive and spontaneous. In other words, this experiment provides a plausible depiction of the brain while in a state of "flow" or in the "zone."

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Practice, practice, practice

As far as we can tell, only human beings achieve this kind of high-order mental state. Although this study was focused on the biology of that mental state, it also demonstrated the value of practicing! After all, great jazz players can compose music on the fly only because they have mastered their instruments. They do not need to devote much conscious effort to finding the notes. Their playing is as automatic as speech.

Based on one small study, it is too early to declare that the medial prefrontal cortex is the seat of jazz, let alone all human creativity. But Drs. Limb and Braun have helped demonstrate that meaningful human work and play result from highly evolved human biology rather than magic.

Harvard Health Letter

Music to their ears it is not

Tone deafness may be caused by differences in connections between parts of the brain.

September 2007
Reviewed March 25, 2015

Many of us can't sing very well, and we don't need Simon Cowell to tell us. We mouthed our way through school chorus and the singing parts of religious services. Even now, we belt it out only in the shower or in the car—alone, with the windows closed. We consider ourselves tone deaf, and we have plenty of company: about one in seven people counts themselves among the tone deaf.

But are we? Being tone deaf tends to be equated with an inability to sing, yet there are plenty of terrible singers who hear music just fine and enjoy listening to it. If the term is used in a stricter—and more literal—sense to mean people who can't perceive music, the numbers get smaller. Using music listening tests, researchers have found that only one in 20 people is truly tone deaf. The main deficit for such people is an inability to hear differences in pitch—how high or low notes are—so following even the simplest melody is hard work, if not impossible.

In research circles, serious tone deafness is referred to as amusia. If someone is born that way, it's called congenital amusia. Both Milton Friedman and Che Guevara are thought to have had congenital amusia, which, if true, might be the only thing they had in common.

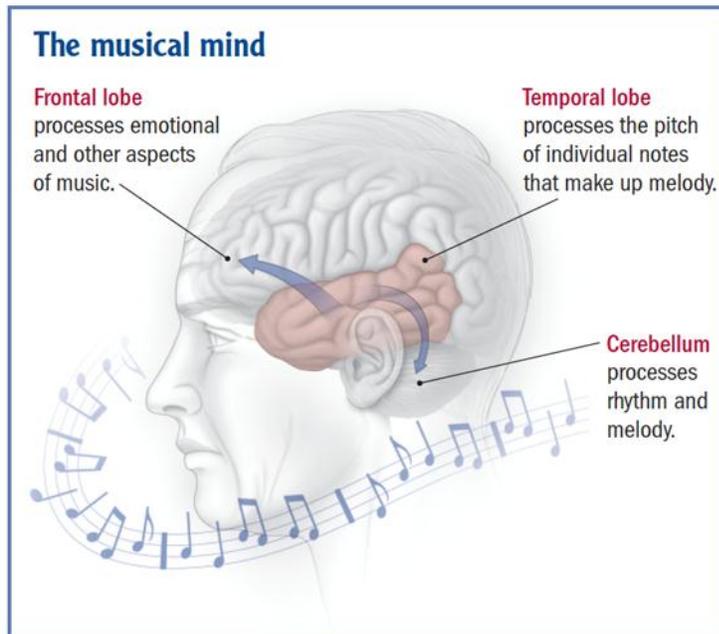
There's been a boomlet in amusia research. Researchers at the University of Montreal have developed a series of tests, called the Montreal Battery for the Evaluation of Amusia, which makes it possible to tease apart different types of musical deficits. And sophisticated imaging tests are letting researchers compare the brains of amusics against people with normal musical abilities.

Much of this research is motivated by simple curiosity about how the brain works and the nature of music. As far as we know, no one is working on a cure for tone deafness. But the scientists involved in the research say that amusia may serve as an important model for other

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developmental disabilities and that by unlocking its mysteries, they'll make discoveries about problems such as learning disabilities.



Pitch problems

Western music is organized into semitones, or half steps, such as the difference between F and F-sharp or between B and B-flat. Most people have no problems distinguishing semitones; in fact, most of us can distinguish between notes that are separated by a fraction of a semitone.

But people with amusia often need a much larger spread before they can reliably hear a difference in

pitch. In many cases, the difference must be close to an octave—which, for example, is the distance between the first two notes of "Over the Rainbow," the famous song from *The Wizard of Oz*.

It's not simply pitch in isolation that amusics have difficulty with. They don't hear pitch direction or pitch contour—the various ups and downs that form a melody—very well. Experiments have shown that amusics have an especially difficult time picking out pitch changes in the context of a musical phrase.

Some people with amusia seem just as clueless about rhythm as about pitch and melody. If you saw the movie *Motorcycle Diaries* about Che Guevara, you may remember the scene when he dances a tango while everyone else is doing a mambo. Yet several experiments have shown that amusics have a pretty good sense of rhythm if the music played is monotone. It's very possible that when people with amusia listen to a normal piece of music, the pitch changes throw them off, so they also stumble on the music's rhythm.

Could it be a bad connection?

There does seem to be an inherited component to being tone deaf. In a study that is often cited, researchers examined the music perception of identical and fraternal twins using the "distorted tunes" test, which preceded the Montreal tests. The identical twins were more likely to have similar test scores. Using standard statistical techniques for twin studies, the researchers estimated that musical listening ability is 70% to 80% heritable.

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In general, music seems to be handled by the right side of the brain. Brain scans haven't revealed any major anatomical differences in people who are tone deaf. It has taken more sophisticated tests to uncover some subtle variations. An imaging and statistical technique called voxel-based morphometry calculates the density of brain tissue. In a study comparing amusics to people with normal musical ability, researchers used it to measure the white matter (which consists of connecting nerve fibers) between the right frontal lobe, where higher thinking occurs, and the right temporal lobe, where basic processing of sound occurs. The white matter of the amusics was thinner, which suggests a weaker connection. Moreover, the worse the amusia, the thinner the white matter.

This finding is consistent with the notion that our brains use a "distributed network" when we listen to music. There may, indeed, be some sort of "pitch center" in the temporal lobe where the simplest properties of pitch are recognized and processed. But once you add in melody, chords (several pitches played at the same time), counterpoint, scales, and other "rules" of music, more brain power is needed, so the frontal lobes are recruited.

Rhythm and movement are closely related, and several studies show that the cerebellum, the part of the brain that integrates sensory perceptions and movement, may be activated by rhythm. Of course, music often provokes a strong emotional response, so the parts of the brain that cause emotions also join the orchestra. In one experiment, music that produced "chills" caused more blood flow in reward-seeking areas of the brain—the same areas that "light up" in response to food, sex, and recreational drugs. This finding could be an argument for or against rock 'n' roll, depending on your point of view.

It's an open question how specialized music processing is. Some experts believe there's a great deal of overlap between music and speech—which also has elements of pitch and rhythm—and how the brain handles them. In their view, we're merely harnessing our considerable talents for sound and language when we listen to music.

Others believe that musical perception and thinking happen quite separately from other functions, and our brains are predisposed toward developing centers and networks dedicated exclusively to the job. They cite case reports of brain injuries that robbed people of language but left their musical abilities intact. Of course, people with amusia have the opposite problem: Their language processing seems fine, but music is Greek to them. The existence of amusia when other perceptions and abilities are normal is more evidence that music processing is autonomous.

When people with amusia have been tested on their ability to discriminate between sentences that differed in intonation, they've done just as well as controls. But when words are replaced by notes following the same variations in pitch, they get confused. Researchers believe that spoken speech may be full of stress and timing differences that allow amusics to understand it.

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The flip side: Heads full of music

Some people's brains can't process music, but others have just the opposite problem: brains that "play" music even when it's not there to be heard.

Musical hallucinations are much more than the experience we've all had of getting a tune stuck in our heads: The music sounds real and vivid and not the least bit imagined to the person having the hallucination. Voices in combination with instrumental music seem to be more common than instrumental music alone. People tend to experience familiar songs from their pasts.

Musical hallucinations can occur with other hallucinations and psychoses (breaks with reality). Several years ago, Israeli investigators found that a fifth of the 190 psychiatric outpatients they studied reported having musical hallucinations. And there are scattered case reports of people with epilepsy having musical hallucinations during seizures.

But people with no mental illness or brain injury have also been known to have musical hallucinations—and it's the only type of hallucinations they have. In such cases, the cause often seems to be hearing loss. Sometimes there's a similar phenomenon with loss of sight called Charles Bonnet syndrome. People experience detailed pictures of familiar people and places even though their eyes aren't functioning.

One theory about musical hallucinations—and hallucinations more generally—is that normal sensory inputs inhibit traces of memory left in the brain. When people can't hear (or see), the inhibition disappears, so the memory, in modified form, is experienced as a hallucination.

To learn more...

This information was prepared by the editors of the Harvard Health Publications division of Harvard Medical School. It is excerpted from the September 2007 issue of the *Harvard Health Letter*, available at hvr.d.me/Jwy02.

Musical Medicine

Melodies can help heal disharmonies in speech

by David Cameron

A lesion on the elderly man's left frontal lobe, damage from a massive stroke, has robbed him of the ability to speak. The clinician sitting opposite him asks him to repeat a simple phrase: "Happy birthday to you." The man struggles, but only manages, "En oh en oh en oh."

The clinician then asks him to sing the phrase. Holding his left hand, moving it rhythmically, she initiates the song. After a few attempts, she's silent, and he sings it as clearly as anyone carrying a cake with lit candles. The clinician then asks him, again, to speak the phrase. Without a hitch, he repeats, "Happy birthday to you."

In less than two minutes, an extraordinary feat has occurred. Yet for researchers like Gottfried Schlaug, HMS associate professor of neurology and director of the Music, Neuroimaging and Stroke Recovery Laboratories at Beth Israel Deaconess Medical Center (BIDMC), such events aren't new. Medical literature going back a century describes stroke victims who have regained aspects of speech through melodic intonation therapy. "The difference," Schlaug says, "is that now we have the neuroimaging tools to investigate what occurs in the brains of people who relearn language through song."

These tools reveal substantial overlap between areas of the brain that process music and language. Damage to the left hemisphere significantly impairs speech. And although the right hemisphere has some capacity for language, it responds best to clearly structured information, such as melodies. Layering language over melodies engages the right hemisphere's latent language capacity.

Schlaug speculates that when people cycle between singing and speaking, the melodic contour and continuous voicing enable the right hemisphere to vocalize words and phrases, creating a kind of language-smuggling Trojan horse. By moving the elderly man's left hand, the clinician helps him connect sounds to actions, sketching auditory motor maps into the right side. If a patient rehearses this entire process long enough, the brain's right side eventually compensates for the impaired left—and even changes structure. "Ultimately," Schlaug says, "we trick the right hemisphere into learning how to speak."

Neurologists once embraced the theory that the right hemisphere of the brain housed a person's creativity, while the left hemisphere processed information such as math. Musicians, then, should be highly right brain lateralized. In the early 1990s, Schlaug tested that theory. Using MRI technology to scan the brains of both musicians and nonmusicians,

he and his colleagues discovered that the brains' morphologies revealed the opposite. Musicians, on average, were more left brained; those with perfect pitch were the most left brained of all.

Schlaug has since focused on the planum temporale, which is part of the auditory cortex. The planum temporale has a more pronounced leftward asymmetry in musicians with perfect pitch than in musicians without perfect pitch and in nonmusicians.

"Professional musicians practice their skills many hours a day, for many years," says Schlaug. "We think of musicians as auditory-motor athletes whose long-term training has an effect on brain function and structure."

These findings launched Schlaug onto a trajectory of collaborations with researchers such as Psyche Loui, an HMS instructor in neurology at BIDMC and a violinist with perfect pitch, and David Alsop, a musician who is also an HMS associate professor of radiology at BIDMC. As Schlaug, Loui, Alsop, and colleagues use the latest imaging technologies to study the brains of musicians and nonmusicians, the unanswered questions mount. How, for example, does music affect brain adaptation, reorganization, and even plasticity? The team is also in the last phases of a longitudinal study on the neurobiological effects on children of learning to play an instrument.

And finally, what about professional musicians? Schlaug suspects they are not born with the natural advantage of an auditory-motor system that enables them to play a musical instrument. Instead, given the plasticity of the brain, particularly at a young age, their continued musical practice likely leads to brain changes that can be detected by modern imaging techniques. For many of us this is good news. "Unless you're tone-deaf," Loui says, "you probably have some unconscious musical abilities even if you can't sing in tune."

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Field Notes

A fascination with baby babble leads a pediatrician to birdsong

by Perri Klass

At well-baby visits, when it's too early to ask about spoken words, I always ask about babble.

You want to hear that a four-month-old is producing babbling noises, heavily oriented toward vowel sounds. You hope that by around seven months, the baby is progressing to "canonical babbling," which involves the production of what sounds like syllables, complete with consonants: ba, da, ma.

Why worry about a baby who doesn't babble?

She may be signaling that there's something getting in the way of speech development—a hearing problem or a general developmental delay. And to parse a baby's silence, you would surely ask the medical students or the residents, "If the baby's hearing is perfect, and the baby's development seems absolutely normal, what should be your next concern about this baby who isn't babbling?"

You would pause, hoping someone says, "Is anybody talking to her?"

You then would review how much goes into those deceptively simple baby noises—sensory, motor, cognitive, social—and how many things can go wrong.

A couple of years ago, thinking about these exam room interactions, I reviewed some of the scientific literature on human baby babble, a topic that has attracted researchers interested in speech and hearing as well as those interested in learning and the brain. Babies must learn to talk; their bodies and brains are, in fact, designed to learn this skill. Speech acquisition is a miracle of interlocking systems, ranging from the muscle control and laryngeal gymnastics involved in producing immature sounds, to the iterative process of refining those sounds into recognizable words, to the cognitive work of arranging those words into sentences and weaving those utterances into social interactions and relationships. If something goes wrong—in oral-motor muscles' coordination or development, in acoustic and auditory processing, in cognition and memory formation, or in social stimulation—speech and language may be absent or delayed, putting the child at risk of isolation from the give and take needed to be a member of a family, a part of a culture, and ultimately, an engaged citizen of society and the world.

To further explore the science of babble, I spoke to experts who study speech and hearing, and learned about experiments that attempt to sort out how babies use their muscles to create sounds, and how they then practice repetition to bring those sounds closer to speech. Other researchers described the ways babies mimic the sounds they hear and mentioned the importance of the deliberate, exaggerated speech that has been called “motherese,” or “parentese.” Neuroscientists looking at speech see the connections between auditory and motor areas in the human brain, and study how babies learn by trial and error the oral-motor differences between producing specific meaningful sounds.

All of this made sense; these avenues of inquiry converged again on those exam room questions and concerns over sensory, motor, cognitive, and social development. But what I hadn’t expected was that so many of those roads also led to birdsong. Or that birdsong would present so many answers, and new questions.

Voice Lessons

Many animals make sounds of a predetermined, characteristic nature no matter how they are raised—even if raised in isolation or with a different species. They are, in short, wired for their sounds. Babies and many songbirds, by comparison, have the muscular hardware and the neural software for making sounds, but the specific speech and song they produce are heavily dependent on learning.

Like humans, songbirds have critical developmental periods during which they are able to learn to reproduce the sounds made by those around them. Cross-fostering experiments have shown that many types of birds raised in a different family or species can reproduce, with some constraints, the songs they hear, not the songs of their biological origins. And of course, it doesn’t matter where a human baby is born, or what language that baby’s biological parents speak; the baby will learn to speak the language he grows up hearing.

Researchers have long been fascinated by the parallels between the imperfect, immature songs of young birds and the early attempts at speech made by human babies.

“From the perspective of human speech development, the early stages of learning are the most interesting, when both birds and humans go through a stage of babbling, uttering highly variable vocalizations,” says Bence Ölveczky, the John L. Loeb Associate Professor of the Natural Sciences at Harvard University. Ölveczky studies motor learning in animals, including song production by birds. He is particularly interested in the basal ganglia, which play an important role in the bird’s ability to go from vocal experimenting, the equivalent of babble, to producing mature song.

For those experiments, Ölveczky studies zebra finches, songbirds most often found in Australia. Although smaller than your closed fist, these birds are loud and lusty singers, even in captivity. Or at least the males are. As with many songbird species, the males sing, learning their songs from their fathers, but the females do not.

Ölveczky calls zebra finches “expert animals,” pointing out that their brains are specialized for learning the complex song sequences they produce. “We can learn a lot from expert animals,” he says. “They have evolved dedicated neural circuitry optimized for a particular task. As mammals, for example, we are more generalist animals, our brains are less differentiated, we’re sort of half good at a lot of things. Birds have much more differentiated brains. They’re experts.”

Takao Hensch, an HMS professor of neurology, studies the mechanisms of critical periods of brain development, the windows of time when the brain is particularly sensitive to experience. His laboratory is looking at mice to see what turns these critical periods on and off.

According to Hensch, much important information on critical periods has come from birds. The song of the zebra finch, once learned, is crystallized for life. “Other birds, like canaries, are seasonal singers and repeat this process annually,” he says. “That’s how neurogenesis in the brain was discovered—certain songbirds reopen the critical period, and they actually have a rebirth of neurons.”

Allison Doupe ’79, a professor of psychiatry at the University of California, San Francisco, has also studied the cortical basal ganglia pathway in zebra finches. Her research team has focused on this particular part of the brain because in birds, as in humans, the basal ganglia are essential for learning and controlling movements—including the complex set of movements needed to produce a characteristic mature song.

“We study songbirds because they are vocal learners and because they have brain areas specialized for producing the song and for learning the song,” says Mimi Kao, a postdoctoral fellow at UCSF who is part of Doupe’s research team. “If you have a juvenile bird with a damaged circuit, the bird will never produce a good copy of the song.”

Doupe and her colleagues have looked at the neuronal detail of the pathway—recording the activity in the brain while the bird is singing and then examining the patterns of neuron firing—and have demonstrated that these patterns are highly sensitive to social context and to the stimulation that the bird receives.

“When males are singing by themselves, the brain activity varies from one song to the next,” says Kao. “When a male sings to a female and he’s singing the same song, the activity looks much more stereotyped and precise.”

Or, as Doupe and Patricia Kuhl, a professor in the Department of Speech and Hearing Sciences at the University of Washington, Seattle, put it in a landmark article published in the Annual Review of Neuroscience in 1999, “the social factors required by zebra finches can come in a variety of modalities, all of which may serve to open some attentional or arousal gate, which then permits sensory learning.” They went on to write, “Infants engaged in social interaction appear to be highly aroused and attentive, which may play a role in their ability to react to and learn socially significant stimuli.”

Duets

So, babble matters, and birdsong is important for thinking about babble—as model, as mechanism, even as metaphor. People who study baby babble and those who study birdsong are aware of the neurological parallels. There are “baby researchers” who cite birdsong, and “bird researchers” who cite babble.

I talked with Michael Goldstein, who cites, and studies, both.

Goldstein is an associate professor of psychology at Cornell University. In a building on that campus, he and Jennifer Schwade, a research associate, run the Behavioral Analysis of Beginning Years lab. Yes, the B.A.B.Y. lab. Upstairs, they study human infants, and adults; downstairs they study young and mature zebra finches. I spent a couple of days in that building, moving from floor to floor, watching the researchers study the babies and listening to the songs of the finches.

In the upstairs lab, the researchers conduct baby-parent studies, looking at the ways that babies elicit speech from their parents and how the social context of this kind of back and forth affects the baby’s skill as a learner of speech and language. Downstairs, they study zebra finches, concentrating on how social interactions shape the vocal learning that produces the song.

Thus, two very strong strands of inquiry twist together: the people who look at what is called song production in the birds are the same people who look at how human babies learn to master and interpret the language of the world around them.

Much of what the researchers study in the human babies concerns the effect that the mother’s responses have on the baby’s vocalizations and on vocal learning. “The caregiver

reacts,” says Goldstein, “and the infant modifies the sounds. As the sounds become more speechlike, the caregiver is more likely to react. So babbling has a crucially important function, but you’re only going to see it if you study babbling in a social context.”

It turns out it’s also best to study the birds in a social context. Goldstein’s team studies the ways that adult birds, both males and females, react to immature birdsong, and the ways that those reactions shape a young bird’s learning. This involves studying not only the song that a father, or other adult male, may produce, but also the behaviors, such as wing movements and so-called fluff-ups, that convey a response from a mother or other avian female. Upstairs and downstairs, development is studied as part of a social system, in which a young learner’s immature utterances elicit responses that then help the vocalizations develop and mature.

Score Marking

All of the researchers I contacted are people who love to think about the whys and wherefores of human speech. Talking with them or reading their research takes you from brain structure and function to learning and memory, and from statistical learning—the neurological mathematics of frequency, the process by which babies’ brains figure out parts of speech and syntax—to how simple mechanisms, such as parental responses to a baby’s sounds, can help generate complex communications.

While at Cornell, I listened carefully to the songs of the zebra finches as the researchers pointed out the immature, plastic song of young birds and the mature song of the adults, song that has been shaped by stimulation and social interaction. Now, in the clinic, I again listen carefully—and, perhaps, with added awe—to babies as they babble their way toward language and communication.

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Music as fine medicine

Medical School students show their creative talents in Arts First

April 29, 2013 | Editor's Pick



By Aaron Lester, Harvard Correspondent

When the future doctors picked up their instruments Thursday evening, they were the musical kind. The Joseph B. Martin Lounge in Vanderbilt Hall on the campus of Harvard Medical School (HMS) had been transformed into an arts space and performance venue. Though all the performers were HMS students, there was not a white coat among them. The evening was dedicated to their art.

“This night is to experience what we all do [outside of class], together,” said Christopher Lim ’10, an organizer of the event, an accomplished pianist and composer, and a first-year HMS student.

The event was part of the 21st annual Arts First festival, a four-day celebration of the visual, literary, and performing arts at Harvard that concluded Sunday night. Until now, all of the Arts First events have occurred on the Cambridge campus. This year HMS, which had embraced the arts in the past, decided to bring the festival across the Charles River to showcase the talents of its accomplished artists, who also are in training.

Lisa Wong, assistant clinical professor of pediatrics at the Medical School, set the ball in motion. Thinking that HMS should have a role in the festival, she approached Lim and Madelyn Ho '08, also a first-year medical student with an arts pedigree, and asked, "What do you think?"

"They picked up the ball and ran with it," said Wong, who in addition to being a pediatrician and professor is a violinist and pianist. For the past 20 years, she has been the president of the Longwood Symphony Orchestra, whose members are predominantly medical professionals.

Lim and Ho find that arts and medicine are complementary pursuits.

"In practicing music, you spend hours alone listening to yourself, and paying attention to the most subtle, ineffable aspects of the sound you produce. It's an extreme form of concentration and takes incredible patience. That kind of focus translates into the medical setting," said Lim, who completed a master's degree in performance before pursuing his M.D.

Ho, who performed professionally for three years with the Paul Taylor Dance Company, said that in both medicine and dance there is a "fluidity" when moving from the subjective to the objective. "In dance," Ho said, "as I am visualizing a dance or movement, I am able to move fluidly and constantly between 'seeing' myself as if from the outside like an audience member and feeling what the movement is like within myself."

Ho said there is a parallel in medicine, where she needs to be able to observe the symptoms of a patient, but also put "myself in their position to understand their experience ... on a very personal level."

The idea that art can enhance medicine isn't entirely new to Harvard, said David S. Jones, the A. Bernard Ackerman Professor of the Culture of Medicine, a joint position between the Faculty of Arts and Sciences and the Faculty of Medicine. "But it's never been organized. "There are people in Cambridge who are offering courses in the literature of medicine, while at the same time there are clinicians at the Longwood campus also teaching the literature of medicine," Jones said.

That's why Jones, Wong, and other members of an ad hoc committee meet every other month to bring attention to the value art can add to HMS.

Cultivating an atmosphere steeped in art is a “valuable and interesting” thing to be doing, Jones said. “Not only is it valuable in its own right as a form of artistic expression, but it can enhance the community, and could possibly contribute to patient care as well.”

Wong hopes to create a resource for medical students to reassure them that they don’t have to give up their art when they become doctors. “In fact, we believe that being an artist enhances your ability to be a good doctor,” she said. She also wants to “promote the exciting research going on, like the neuroscience of music, arts and autism.”

For several years, HMS has offered an elective, “Training the Eye,” that is meant to improve the future doctors’ observational skills by seeing and talking about art during trips to the Museum of Fine Arts.

Physicians also come to the class to discuss the connection between art and their clinical practice. “For example,” said Ho, who is taking the class this semester, “we had a radiologist discuss how contours are important for looking at chest radiographs, and a neurologist discuss how noticing asymmetries in the face are important manifestations of different types of medical issues.”

At Vanderbilt Hall Thursday, the performances ranged from the sublime and masterful to the satiric and simply cool. A Chopin piece performed by Lim and a Puccini aria sung by Jacqueline Boehme HMS ’15 coexisted with a parody rap video and avant-garde poetry.

“It seems that every year there are more talented, accomplished, and innovative students coming into the medical school,” said Wong. “Which makes me feel even more inspired to get this work off the ground and help them in any way we can to continue their art form as they become the next generation’s clinicians.”

Arts First at HMS is sponsored by Arts&Humanities@HMS and by the Ackerman Program on Medicine & Culture.

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Music on the brain: Researchers explore the biology of music

By William J. Cromie
Gazette Staff

Babies come into the world with musical preferences. They begin to respond to music while still in the womb. At the age of 4 months, dissonant notes at the end of a melody will cause them to squirm and turn away. If they like a tune, they may coo.

Scientists cite such responses as evidence that certain rules for music are wired into the brain, and musicians violate them at the risk of making their audiences squirm. Even the Smashing Pumpkins, a hard-rock group, play by some of the same rules of harmony that Johann Sebastian Bach did in the 18th century.

"Music is in our genes," says Mark Jude Tramo, a musician, prolific songwriter, and neuroscientist at the Harvard Medical School. "Many researchers like myself are trying to understand melody, harmony, rhythm, and the feelings they produce, at the level of individual brain cells. At this level, there may be a universal set of rules that governs how a limited number of sounds can be combined in an infinite number of ways."

"All humans come into the world with an innate capability for music," agrees Kay Shelemay, professor of music at Harvard. "At a very early age, this capability is shaped by the music system of the culture in which a child is raised. That culture affects the construction of instruments, the way people sound when they sing, and even the way they hear sound. By combining research on what goes on in the brain with a cultural understanding of music, I expect we'll learn a lot more than we would by either approach alone."

Besides increasing basic understanding, Tramo believes that studying the biology of music can lead to practical applications related to learning, deafness, and personal improvement. For example, there's evidence that music can help lower blood pressure and ease pain.

Looking for a music center

A human brain is divided into two hemispheres, and the right hemisphere has been traditionally identified as the seat of music appreciation. However, no one has found a "music center" there, or anywhere else. Studies of musical understanding in people who have damage to either hemisphere, as well as brain scans of people taken while listening to tunes, reveal that music perception emerges from the interplay of activity in both sides of the brain.

Some brain circuits respond specifically to music; but, as you would expect, parts of these circuits participate in other forms of sound processing. For example, the region of the brain dedicated to perfect pitch is also involved in speech perception.

Music and other sounds entering the ears go to the auditory cortex, assemblages of cells just above both ears. The right side of the cortex is crucial for perceiving pitch as well as certain aspects of melody, harmony, timbre, and rhythm. (All the people tested were right-handed, so brain preferences may differ in lefties.)

The left side of the brain in most people excels at processing rapid changes in frequency and intensity, both in music and words. Such rapid changes occur when someone plucks a violin string versus running a bow across it.

Both left and right sides are necessary for complete perception of rhythm. For example, both hemispheres need to be working to tell the difference between three-quarter and four-quarter time.

The front part of your brain (frontal cortex), where working memories are stored, also plays a role in rhythm and melody perception.

"It's not clear what, if any, part these hearing centers play in 'feeling' music," Tramo notes. "Other areas of the brain deal with emotion and pleasure. There is a great deal of effort going on to map connections between the auditory cortex and parts of the brain that participate in emotion."

Researchers have found activity in brain regions that control movement even when people just listen to music without moving any parts of their bodies. "If you're just thinking about tapping out a rhythm, parts of the motor system in your brain light up," Tramo notes.

"Music is as inherently motor as it is auditory," he continues. "Many of us 'conduct' while listening to classical music, hum along with show tunes, or dance to popular music. Add the contributions of facial expressions, stage lights, and emotions, and you appreciate the complexity of what our brain puts together while we listen and interact with music in a concert hall or mosh pit."

Practical applications

Understanding the biology of music could allow people to use it better in medical and other areas where evidence indicates music produces benefits beyond entertainment.

Following heart bypass surgery, patients often experience erratic changes in blood pressure. Such changes are treated with drugs. Studies show that those in intensive care units where background music is played need lower doses of these drugs compared with patients in units where no music is played.

Scientists and medical doctors are investigating the value of musiclike games to aid dyslexics. When dyslexics play a game that calls for responses to tones that come very fast, it reportedly helps them to read better. "The approach is controversial," Tramo admits, "but there's enough favorable evidence for researchers to continue testing it."

Some hospitals play soft background music in intensive care units for premature babies. Researchers have found that such music, as well as a nurse's or mother's humming, helps babies to gain weight faster and to leave the unit earlier than premies who don't hear these sounds.

On the other end of the age scale, music has been used to calm Alzheimer's patients. At mealtime in nursing homes or hospitals these people may be difficult to organize. Fights even occur. The right kind of music, it has been demonstrated, reduces confusion and disagreements.

Investigators have also found that music lowers blood pressure in certain situations, and it seems to increase the efficiency of oxygen consumption by the heart. "One study showed that the heart muscle of people exercising on treadmills didn't work as hard when people listened to music as it did when they exercised in silence," Tramo notes.

Then there are endless anecdotes about athletes using music to enhance their performance. Pitcher Trevor Hoffman of the San Diego Padres, for example, listens to AC/DC to get psyched up in a game. Tramo ran to "Brown Sugar" by the Rolling Stones when he won a gold medal in the 100-yard dash in high school. To determine how much difference music makes, however, the performance of an athlete who listens to music would have to be compared with that in games when he or she didn't listen.

Tramo believes that music and dancing preceded language. Archaeologists have discovered flutes made from animal bones by Neanderthals living in Eastern Europe more than 50,000 years ago. No human culture is known that does not have music.

"Despite this, large gaps exist in our knowledge about the underlying biology," Tramo points out. We don't know how the brain decides if music is consonant and dissonant. We don't know whether practicing music helps people master other skills such as math or

reading diagrams, although evidence that merely listening to Mozart in the womb improves IQ scores is weak or nonexistent.

Tramo made a choice between composing music and studying its biology at the end of medical school. When he and his roommate at Yale recorded a demonstration album called "Men With Tales," both RCA and Columbia Records said they wanted to hear more. But Tramo decided to stay with medicine. He didn't quit music though. Recently, he and his band recorded a song, "Living in Fantasy," which ranks in the top 40 of MP3 (accessible by computer) recordings made in Boston.

"I'm working on the neurobiology of harmony," Tramo says, "but I find time to compose and play music. Bringing the two together is like bringing together work and play."

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Music as Medicine

American Psychological Association

<http://www.apa.org/monitor/2013/11/music.aspx>

Music as Medicine for the Brain

Matthew Shulman, US News

<http://health.usnews.com/health-news/family-health/brain-and-behavior/articles/2008/07/17/music-as-medicine-for-the-brain>

Between Music and Medicine

Robert Gupta, TED Talks

https://www.ted.com/talks/robert_gupta_between_music_and_medicine?language=en

Music as medicine: Docs use tunes as treatment

Bill Briggs, NBC

http://www.nbcnews.com/id/30990170/ns/health-health_care/t/music-medicine-docs-use-tunes-treatment/#.VSQp-ZTF_AE

American Music Therapy Association

Official Website

<http://www.musictherapy.org/>

Playing for time: Can music stave off dementia?

Elizabeth Landau, CNN

<http://www.cnn.com/2013/08/31/health/music-dementia-link/>

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