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DISCOVER MAGAZINE
Vol. 22 No. 8 (August 2001)

The Genetic Mystery of Music

Does a mother's lullaby give an infant a better chance for survival?

By Josie Glausiusz

Take a step toward the wall mural in psychologist Sandra Trehub's lab, and you'll find yourself in a tropical rain forest, enveloped by a riot of purple flowers, lush green ferns, oversize butterflies and bees. The only thing missing is the cry of macaws. But take a step back, and you're likely to hear other cries - those of babies. And then it all makes sense - the forest, the Teletubbies, the toy trucks scattered on the floor, the graceful mobiles hanging from the ceiling, the picture books and bright posters. This is a lab where mothers and very small children feel comfortable. It is also a lab with a very specific quest, a search within the infant brain for the biological roots of music.

Thousands of babies have passed through this facility at the University of Toronto at Mississauga in the past 25 years, and each one has departed with a diploma attesting to his or her contribution to "the advancement of science and the understanding of child development." Here Trehub has observed parents singing to their babies and watched how the babies respond to those songs (they are mesmerized). She has studied the history and universality of lullabies (they sound the same the world over). She has documented the power of a mother's singing (it decreases stress hormones in her child). She also has found that babies seem to have an innate appreciation for music.

In one study, for example, a pudgy-faced, redheaded 8-month-old sits on his mother's lap in a soundproof booth, fascinated by the fluffy toy a smiling lady is waving in his face. In the corner, an audio speaker spits out a tinny little tune over and over - the sequence of notes arranged on the Western major scale (do re mi fa sol la ti do) familiar to fans of The Sound of Music. At first, the baby seems indifferent. Then an anomalous note - one that doesn't belong in the scale - intrudes on the recording, and he suddenly turns his head toward the speaker. He'll do this repeatedly when the wrong note is played.

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Some might argue that the baby has learned since birth to recognize notes common to Western music. But a second experiment casts doubt on that assertion. This time the tune played has an inherently musical structure, yet it is built on an invented scale unfamiliar to Westerners. Nevertheless, Trehub's infant subjects still pick out anomalous notes - even better than adults do. "I'm convinced that there's a biological basis for the babies' abilities," Trehub says. "Music making is so successful in managing the baby's state and getting the baby to sleep that it makes the task of caring for the baby easier. It takes the edge off this enormous burden."

A baby that's better cared for is more likely to survive to adulthood and reproduce. And that gets to the crux of a debate that has galvanized evolutionary biologists, psychologists, and neuroscientists alike. If the ability to appreciate music is ingrained in the human brain, could music making have evolved to help us survive and reproduce? Is it akin to language and the ability to solve complicated problems, attributes that have enhanced human survival? Or is it just "auditory cheesecake," as cognitive scientist Steven Pinker of the Massachusetts Institute of Technology has called it - a phenomenon that pushes pleasure buttons without truly filling an evolutionary need?

No one has ever seen a need to build a robot equipped to appreciate music, says Steven Pinker of MIT. This suggests that music, unlike eyesight, is not essential for long-term human survival.

Sometime between 43,000 and 82,000 years ago, a Neanderthal living in a cave in what is now Slovenia fashioned a flute from the femur of a bear. Simpler instruments such as rattles and drums probably preceded it, and singing probably began even earlier - perhaps as long as 250,000 years ago.

Why? Why has music spread to every country and every people in the world? Why is music used to rouse armies, praise God, and bury the dead? Charles Darwin, for one, thought music helped humans find mates. In his 1871 book, The Descent of Man, he suggested that early men and women, unable to express their love in words, "endeavored to charm each other

with musical notes and rhythm," as birds do. But proof is still lacking.

Geoffrey Miller, an evolutionary psychologist at the University of New Mexico, has looked at thousands of jazz, rock, and classical music albums and noted the age and sex of the musicians. In every genre of music, he says, men produce about 10 times as much as women, and their output peaks at around age 30 - near the time of their peak reproductive years. "Good musicians, particularly good singers, attract sexual interest," Miller says. "Successful male musicians are notoriously promiscuous and tend to produce a lot of children - and that's how the genes for musical ability tend to be passed on."

Still, there's no evidence that women are any less musically inclined than men. Women in all cultures sing to their infants, Trehub points out, and there is no hard evidence that talented musicians are particularly prolific. In fact, Hajime Fukui, an evolutionary psychologist at Nara University of Education in Japan, maintains that music reduces sexual activity. In one study, Fukui gathered 35 male students and 35 female students, measured their hormone levels, and then played them half an hour of music of all types. Afterward, Fukui found, the men's testosterone levels had gone down and the women's had gone up. Silence had no effect.

Fukui believes that when early humans formed communities, they had to develop ways to alleviate sexual tensions. "We may assume that their solution was music," he says. If music lowered testosterone levels in men, it made them less sexually active. If it increased testosterone in women, it made them more aggressive and less social. The net result was less sex, and less sexual tension. "National anthems, work songs, party music, and war music all have the same effect," Fukui says. "They diminish fear, relieve tension, and boost people's sense of solidarity. Music moves people, throws them into a trancelike state, and paralyzes their ability to think logically. We might think that we are the users of music. In fact, we are not the puppeteers but the puppets of music."

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In Sandra Trehub's lab, a clucking chicken or a shuffling puppy greets this 6-month-old baby when she turns her head toward unusual musical notes. Music can also mitigate stress. In one recent study, neurologist Barry Bittman of the Mind-Body Wellness Center in Meadville, Pennsylvania, gathered a group of 10 people and had them beat hand drums for an hour while a music "facilitator" conducted. Afterward, Bittman took blood samples. The drummers, he found, had heightened levels of immune cells called natural killer cells that seek out and destroy both cancer cells and cells infected by viruses. A control group that read in silence experienced no such upsurge.

Bittman believes that group drumming, through its camaraderie, support, exercise, and music making, signals the brain to lower the production of cortisol, a stress hormone secreted by the adrenal glands. Less cortisol has been associated with a heightened immune response and may help the body fight off infection. "I'm not saying I have a cure for cancer," Bittman cautions. "But what I am saying is that we have a very important step in understanding a delightful, enjoyable, and fun way for people to reverse the stress response in a manner that leads us to positive biological changes."

None of that impresses MIT's Steven Pinker. "I think people who argue that music is an adaptation have confused the everyday meaning of the term - meaning something that is beneficial or salubrious - with the biological meaning of the term, which is something that causally increases the rate of reproduction or survival," he says. "Now, it's not enough just to show that something is correlated with reproduction. Wearing a linen suit or driving a Porsche might help you find a sex partner, but that doesn't mean it's an adaptation. What you need to do is show, on sheer engineering grounds and in terms of cause and effect, that some particular trait would lead to an adaptive outcome."

To prove that having two eyes is an adaptive trait, for instance, one first has to use geometry to show that stereoscopic vision enables depth perception. In turn, one can argue that animals that perceive depth are better at foraging, escaping predators, and finding a mate. It's not enough to point out that guitar heroes tend to be sexually successful, or that making music helps foster social unity. One has to explain why "rhythmic plinking sounds," as Pinker calls music, are sexually appealing or conducive to bonding. If music is about sexuality, why do children and the elderly care for it? And if it's all about bonding, why do people like to listen to it alone?

Not every common trait is adaptive, Pinker adds, citing his favorite example: "Let's say someone asked, what's the adaptive value of cheesecake? The answer is, there is none. It's bad for you. But it is a by-product of other adaptations, namely a taste for sweets and fats, which were adaptive in an environment in which sweets and fats were rare." A chemist can prove the adaptive value of sweets and fats by burning them - just as the body does - and measuring the energy released. But cheesecake is a kind of perversion of that process. "What we do with cheesecake is we start off with the fact that the brain is tickled by certain kinds of pleasure. We concentrate them, purify them, pack 'em together to give ourselves a big sensory wallop. We give ourselves pleasure by taking advantage of preexisting pleasure buttons."

Many parts of the brain participate in music making. Musical sounds are processed in the auditory cortex (yellow). Pathways then carry music to areas of the brain that perform (green), anticipate harmonic and melodic changes (pink), feel and remember (orange), and read (blue). Based on an illustration by Mark Jude Tramo, Science, Vol. 291, January 5, 2001. By

the same token, Pinker says, the pleasure we take in music has less to do with its adaptive value than with the value of the pleasure buttons it pushes. The words and rhythms in music take advantage of our propensity for language. The melodies in music may just be elaborations of the simple sounds we make to convey emotion - sighing, laughing, crying, and cooing. Or they may resemble natural sounds (rushing water, birdsong) that were important to human survival. "We know that the auditory system of the brain has to make sense of all the sounds pouring into the ear at once," Pinker says. "People listen hard to try to hear the animal call against the background of the rustling leaves and the other human voices. Maybe music gives you an artificial stimulus that's so easy to carve into components that the brain thinks, 'Aha! I really understand what's going on in the world.' Or maybe it's a combination of all of those."

Pinker agrees that lullabies could be adaptive: They may reinforce certain natural soothing sounds that send a signal to relax. But he has reservations. "If all music were mothers singing to babies, I would accept that theory," he says. "But that's a fraction of all music. And it doesn't explain why a 17-year-old listens to heavy metal."

Not surprisingly, Pinker's views have made him something of a whipping boy in certain musicological circles. At a recent conference on the biological foundations of music at Rockefeller University in New York City, speaker after speaker rose to denounce the analysis in Pinker's most recent book, How the Mind Works. Pinker has long championed the evolutionary roots of language, Trehub says, although "we don't have any more evidence that links language in any direct way to survival; all we have is the belief that it's likely to promote survival." Definitive proof will always be elusive, she says; yet the evidence for music as a survival tool is all around us. "When you have something that's in every possible culture and in every historical period, you have to ask yourself: Why? If it's an accident, why did this accident happen everywhere?"

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Even if music isn't rooted in evolution, there is something about its sheer power to heal and revive the human spirit that seems to set it apart from other arts. In one of his scholarly studies on music and the brain, neurologist Oliver Sacks noted that the philosopher Friedrich Nietzsche continued to improvise at the piano long after he had been rendered mute, demented, and partially paralyzed by tertiary syphilis. Sacks has also testified to the uncanny gift that music has for drawing people out of comas and catatonic states.

No place better demonstrates this power than New York's Beth Abraham health center in the Bronx, home to the Institute for Music and Neurologic Function. Here, twice a week, music therapist David Ramsey plays host to stroke patients who can no longer speak. But they can sing.

One Wednesday morning in the middle of winter, Bertha, a 67-year-old patient with thick glasses and thinning gray hair, sits silently in a wheelchair with a yellow blanket over her knees. Ramsey, a sprightly man of seemingly infinite patience, strides in and says hello. Bertha only smiles faintly: A left-hemisphere stroke has left her all but paralyzed. Beside her sits Keith, a Nigerian-born former university professor in his fifties who until recently refused to leave his room. When Ramsey greeted him, Keith tried to respond, but his words were slurred and indistinct. He, too, has suffered a left-brain stroke.

"Music: companion of joy, balm for sorrow," wrote the painter Vermeer. At Beth Abraham in the Bronx, the balm of music therapy coaxes even stroke victims like these to sing. There's a sadness to the scene that is all too familiar, one that's repeated every day in hospital rooms and nursing home corridors across the country. But when Ramsey picks up his guitar, the room transforms. "Hello. How are you today," Keith and Bertha sing, as the first three chords ring out. Their voices are quavering and tentative at first but seem to gather strength with every measure. "I am feeling fine, thank you. It's good to see you again." Soon they've launched into a repertoire of familiar tunes with a gusto that seems to belie the miserable weather outside. "O what a beautiful morning! O what a beautiful day!" Over on a bench along the wall, two bearded visiting professors and a shy young student pick up maracas and start to sing along: "You are my sunshine, my only sunshine, you make me happy when skies are gray."

Watching them sing - this man and woman so recently incapable of speech - it's hard not to believe there's something in music that runs deeper than speech, something that reaches places mere language can't get to. "The patients, as soon as they see that they can sing, that they can communicate, they break into tears," says Renato Rozental, a neuroscientist at New York City's Albert Einstein College of Medicine. "How is music doing this? I personally don't know."

Rozental plans to use MRIs to study precisely what goes on in these patients' brains. It's believed that healthy areas of the brain compensate for injured parts, enabling the patients to sing. But he knows his work will offer only crude answers. "There are a lot of myths and dreams about music," he says. "The point is that it works." And here even Pinker is willing to concede: "I suspect that music still is a mystery, and we shouldn't fool ourselves into thinking that we understand it. I think it genuinely is an unsolved problem, which is all the more reason not to accept glib explanations without making sure they really cut the mustard, in terms of science."

The Thai Elephant Orchestra recently issued its debut CD. Played on traditional Thai instruments - slit drums, gongs, and large xylophonelike renats - the elephants' symphony, which is accompanied by the animals' haunting calls, sounds a little

like the clatter of church bells ringing. The question is obvious: Are the elephants making music, or is it just noise? One can't tell for sure, yet many animals sing songs with patterns remarkably similar to those found in human music.

The sounds made by humpback whales, for instance, follow a familiar human form: a statement of theme, an embellishment, and then a return to a slightly modified version of the original theme. The intervals between notes resemble those found in human musical scales, and humpback songs contain repeated, rhyming refrains.

Birds use a plethora of well-known musical forms. The canyon wren's trill cascades down the musical scale just like the opening of Chopin's "Revolutionary" ...tude. The songs of the wood thrush accurately follow the traditional Western musical scale. Male palm cockatoos in northern Australia court females by using twigs shaped into drumsticks to bang on hollow logs.

Such evidence suggests that humans did not invent music: It may predate us by tens of millions of years, and it may stimulate deep, primitive parts of the brain - the source, perhaps, of its deep, emotional pull. "Sound production has been part of animal repertoires forever and ever," says Jelle Atema, a flute-playing marine biologist who studies animal signaling at the Boston University Marine Program. "If that represents music for those animals, then we are the latecomers."

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