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How Your Brain Listens to Music

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Your inner ear contains a spiral sheet that the sounds of music pluck like a guitar string. This plucking triggers the firing of brain cells that make up the hearing parts of your brain. At the highest station, the auditory cortex, just above your ears, these firing cells generate the conscious experience of music. Different patterns of firing excite other ensembles of cells, and these associate the sound of music with feelings, thoughts, and past experiences.

That's a sketch of how the brain listens to music -- just a short ditty to outline the complex symphony of activity that governs our perception of everything from Bach to U2. It's also a lot more than was known until recently.

"We know much more about how we see than how we hear," says Mark Tramo, assistant professor of neurology at the Medical School, Ph.D. student, and published songwriter. "What happens in hearing is harder to understand intuitively."

Sound transmitted to the inner ear is broken down according to the spectrum of frequencies that make up sounds. This orderly arrangement of low to higher frequencies is mapped onto the brain much like the way low to high notes are mapped on a piano keyboard. However, not much is known about how the pieces are put back together when we recognize melodies, words, or the scolding sound of someone's voice.

Beyond the working of specific bunches of brain cells, humans may come into the world with a predisposition to enjoy singing and music, just as language capacities seem to be prewired into our heads. Culture and experience also play a major role in how we perceive music. Finally, there's evidence that young children who study music become better problem-solvers than those without such training.

Music on the Brain

After receiving his M.D. degree, Tramo started to study how different kinds of brain damage interfere with normal perception of music and speech. One patient, for example, lost most of his auditory cortex to strokes. He could hear but complained that music and speech were hard to understand. He could not recognize harmonic patterns.

However, part of an area called the auditory association cortex, and some of the brain connected to it, survived injury. Experiments indicated he could still call on implicit knowledge to recognize favorite songs.

"The harmonic context in which he heard chords changed his sensory experience, just as it does in people without auditory cortex damage," says Tramo. "Such cases give us valuable information about how the auditory cortex and connected brain systems integrate what we hear with what we know about meaningful sounds like music."

The activity of our brain during music perception also is being studied using various imaging techniques. For instance, increased flow of blood and oxygen to different brain areas can be seen as people play and listen to music. In addition, studies of animals reveal details of anatomy and the workings of brain cells that underlie music perception.

Tramo, who has copyrighted and recorded 21 songs and one musical, now concentrates on listening to individual nerve cells as they transmit messages about sound from the ear to the brain. Metal or glass electrodes with tips smaller than a few millionths of an inch monitor each cell's electrical activity.

Vibrations in the air created by music and words move thousands of tiny hairs spread atop a spiral sheet, or membrane, in the inner ear. Nerve cells, stimulated to fire by the swaying hairs, send electrical signals from the ear to the base of the brain then up to the cortex.

The membrane where hairs and nerve fibers meet is wound into a three-turn spiral, thick at its inside and thinning toward the outside whorl. Tramo compares it to guitar strings. In both ears and strings, the thick part is tuned to low frequencies, the thinner part to higher frequencies.

That much has been known for 50 years and applies to speech as well as music. What's new is how this marvelous system handles complex sounds like music and speech. Tramo, working with Harvard colleagues Bertrand Delgutte and Peter Cariani, recently found that the timing of sound-cell activity carries information about harmony and melody.

"In everyday musical experience, melody and harmony emerge from the concerted action of auditory nerve cells in the inner ear and brain," he comments. "In nerves that go from the ear to the brain, it's not only how much they fire, but which ones fire and when."

Tramo is now working toward a Ph.D. in neurobiology, studying where in the auditory cortex various pieces of sound information are put together into a meaningful whole.

Is Music Inborn?

The mechanisms for getting music to the brain, and the experience of being moved by it, are completely different, however. The latter involves both biology and culture.

The auditory cortex has connections to the frontal lobe of the brain, just behind the forehead, where much of our capabilities for abstraction, anticipation, and inference sit. Both these areas also boast extensive passageways to other parts of the brain that generate emotions. How these conduits develop probably are influenced by the culture in which we live.

"Music appreciation is definitely a culture-related phenomenon," says Tramo, "but there are universals that characterize it across the globe. All musics are structured around the octave, all cultures sing, and all have songs they associate with certain meanings and emotions. All children love to be sung to. Perhaps, that's why people refer to music as 'the universal language.' "

Such facts argue in favor of the idea that all humans have an inborn capacity to process music. This idea extends a widely accepted, but unproved, theory that humans come into the world with brains already structured for learning language.

Music and Math

Many parents start giving their children music lessons at an early age, and some evidence indicates that this training bolsters their math and problem-solving skills.

Experimenters at the University of California at Irvine compared 3-year-olds who took piano lessons with peers who learned to sing, use the computer, or did none of these things. A few weeks later, the little piano players did better than the other groups at solving puzzles similar to those presented in IQ tests.

Evidence also exists that high school students with a music background do better than their peers on the Scholastic Aptitude Tests (SATs) for college entrance.

Tramo thinks this may work because of "generalization," the principle that studying one subject helps a learner with other subjects. "Music performance involves many cognitive, perceptual, and motor skills," he notes. "These skills can be transferred to different kinds of intellectual activities. Music also allows you to put a lot of emotion into what you play or sing."

There could be other explanations, of course. Intelligent, confident children might excel naturally in both music and math. Many parents who can pay for music lessons can also afford a better education for their offspring.

On balance, however, Tramo thinks that "by bringing out and exercising musical ability in children, you nurture the development of their intelligence."