ditory system changes, creating neural "noise," perhaps by throwing off the balance between inhibition and excitation in the auditory cortex, leading to the perception of sounds that are not there. Also at play might be dysfunctional feedback to auditory brain regions from the limbic system, which is thought to serve as a noise-cancellation apparatus that identifies and inhibits irrelevant signals.

Music treatment seeks to counteract this dysfunction by inducing changes in the neural circuitry. For those with tonal tinnitus, one treatment involves listening to "notched music," generated by digitally removing the frequency band that matches the tinnitus frequency. The notching—pioneered and proved effective by neurophysiologist Christo Pantev and his group at the University of Münster in Germany—might help reverse the imbalance in the auditory cortex, strenghtening the inhibition of the frequency band that might be the source

Everyone Can Gain from Making Music

The perks of learning to play an instrument last for decades

REGINE MAHAUX ALAMY

Think back to your elementary school music class. You absorbed commands from a baton-wielding conductor while deciphering inky notes on a page. You kept tempo with the rest of the band while your contorted fingers sped from key to key. There is no doubt that musical training is a challenge for the brain. And in the past decade an abundance of studies have found that this effort confers cognitive benefits on all who study music, from toddlers to retirees.

Researchers became interested in the effects of music on the brain when a provocative study in the early 1990s claimed that simply listening to a Mozart sonata could make you brainier—so dubbed the "Mozart effect." The finding was never confirmed. Various studies followed that showed listening to music has transient effects on cognitive functions such as spatial ability, speed of processing and creative problem solving—but such effects last only about 10 minutes once the music is switched off. Experts continue to debate whether frequently engaging with music has longer-term effects on cognition. In recent years, new techniques to measure the brain's response to auditory cues in real time have given researchers valuable data to address the issue. "We can see how these ingredients of sound are processed by the brain," says Nina Kraus, an auditory neuroscientist at the Northwestern University School of Communication. Today some evidence suggests that musical training may enhance a suite of cognitive functions, including listening, linguistics, focus and memory, along with spatial, motor and mathematical skills.

Better Reading through Music?

Young children are ripe subjects for research in this field because their brains are primed to develop language skills, which music seems to enhance. Many studies suggest that children who are musically trained have stronger cognitive abilities, including better vocabulary, reading skills and sound perception. Yet these studies leave unanswered the important question of correlation: Are musicians better at certain tasks because of musical practice alone? Or are they drawn to music because they have these skills already or because they come from advantaged backgrounds?

Kraus and her colleagues have conducted a number of studies to address this question. In one experiment published last September, they gathered 44 children aged six to nine from disadvantaged schools in Los Angeles and asked them to participate in musical instruction for two hours a week. One group practiced for one year; the other practiced for two. After administering a battery of neurophysiological tests that recorded their brain activity, Kraus's team found that those who participated in the music program for two years, independent of their age, were markedly better at processing speech syllables—such as differentiating between the sounds [ba] and [ga]—than those who had only one year of training.

As Kraus explains, a key element of literacy is the ability to discern meaningful differences between speech sounds—so studying music, which shares characteristics with speech such as pitch,

of the phantom sound in the first place. Another approach involves playing a series of pitches to patients and then asking them to imitate the sequence vocally. As the patients refine their accuracy, they learn to disregard irrelevant auditory signals and focus on what they want to hear. In time, the stimulus of effortful attention might help the auditory cortex return to its normal physiological state.

For any novel therapy, enthusiasm can sometimes outpace the evidence, and researchers have rightly pointed out that the new music-based treatments must prove their efficacy against the more established therapies. But of all the techniques for addressing neurological disorders, music-based therapies seem unique in their capacity to tap into emotions, to help the brain find lost memories, to let patients resume their place in the world. We are only now beginning to understand the science behind the belief in the power of music to heal. **M**

timing and timbre, may help kids read better. "The study provides the first direct evidence that a community music program for at-risk youth has a biological effect on the children's developing nervous systems," Kraus says. Other experts urge caution when interpreting these results. "We already know that music training makes you a better listener," says psychologist Glenn Schellenberg, who researches music's effect on cognition at the University of Toronto Mississauga. Until researchers have behavioral evidence that kids who get music training become superior at reading or perceiving speech, he explains, the question of whether music can influence language development remains open.

Empathetic Multitaskers

As a musician grows up, other cognitive benefits appear, among them a better ability to multitask, according to a 2014 study by psychologist Melody Wiseheart and her colleagues at York University in Toronto. The researchers recruited 153 university students aged 18 to 31, about half of whom were musicians with about 12 years of formal musical training; the others were nonmusicians. They asked the students to perform multitasking exercises, such as switching between identifying how many numbers were on a screen and indicating which particular number was on the screen or tracking a moving white dot with their mouse while monitoring a flashing set of letters.

"We found that musicians were doing a lot better," Wiseheart says; they were about 30 percent more accurate than the nonmusicians when performing two tasks at once. Wiseheart says that musicianship appears to enhance working memory, which underlies the ability to multitask and can boost skills both in and out of the classroom—when holding numbers in mind to compute an equation, for instance, or avoiding distractions while driving.

Playing in a band or singing in a choir provides another type of benefit important for this age group. Studies show that making music in a group improves communication, coordination, cooperation and empathy among group members. Many of these advantages of musicianship may stretch into adulthood, but some may not. For example, child musicians appear to have better spatial reasoning than their nonmusician peers, but adult musicians do not.

Preventing Age-Related Decline

Many areas in which child and young-adult musicians outperform their nonmusician peers—such as processing speed, memory and attention—also happen to correlate with areas of cognitive decline in old age[1]. A small but growing body of evidence suggests that lifelong musical practice makes our brains healthier as we age—especially in combating hearing loss, which affects an estimated two thirds of adults older than 70 in the U.S. A series of studies by neuroscientist Alexandra Parbery-Clark of the Swedish Medical Center in Seattle and her colleagues found that musicians aged 45 to 65 appear to lack four of the five hallmark declines of speech processing in old age—they maintained consistent and speedy brain responses to speech, for example, and the ability to understand speech in noisy settings.

In addition, studies suggest that older adult musicians tend to have stronger memory, more focused attention and faster brain processing. Although such effects are most evident in adults who have practiced their instrument at least twice a week for 20 minutes a session since childhood, researchers think that such benefits may also exist for less enthusiastic hobbyists. The act of making music appears to be key because it requires the integration of various senses, motor coordination and concentration in a way that even very attentive listening does not.

What all this means is that learning to play a musical instrument is very good for you. And when that practice begins early in life, its positive effects can stretch into old age. "Biologically, our past shapes our present," Kraus says. Both she and Wiseheart hope that educators and policy makers will take note of this research and keep music in classrooms. As Kraus says, "We want to improve human communication by harnessing the brain's ability to change."

—Julia Calderone