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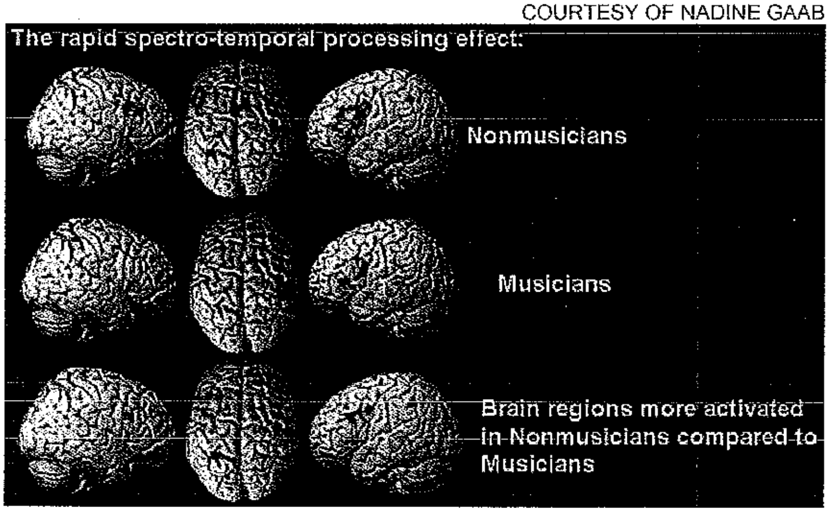
Musical training helps language processing, studies show

BY LISA TREI

COURTESY OF NADINE GAAB



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Nadine Gaab

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In what will be music to the ears of arts advocates, researchers for the first time have shown that mastering a musical instrument improves the way the human brain processes parts of spoken language. The findings could bolster efforts to make music as much a part of elementary school education as reading and mathematics.

In two Stanford studies, researchers demonstrated that people with musical experience found it easier than non-musicians to detect small differences in word syllables. They also discovered that musical training helps the brain work more efficiently in distinguishing split-second differences between rapidly changing sounds that are essential to processing language.

Nadine Gaab, a former Stanford postdoctoral fellow, will present the findings at 9:30 a.m. Nov. 16 at the Society for Neuroscience's annual meeting in Washington, D.C. "These results have important potential implications for improving speech processing in children struggling with language and reading skills," she said. They also could help "seniors experiencing a decline in their ability to pick up rapid changes in the pitch and timing of sounds, as well as speech perception and verbal memory skills, and even for people learning a second language."

The findings of the second study will be published by the Annals of the New York Academy of Sciences next month in an article titled "Neural Correlates of Rapid Spectro-Temporal Processing in Musicians and Non-Musicians." Gaab, now a postdoctoral associate at the Massachusetts Institute of Technology, carried out the experiments in 2004 at Stanford's Psychology Department and at the Lucas Center for Magnetic Resonance Spectroscopy and Imaging.

Co-authors of the paper include Heesoo Kim, a former Stanford master's student; radiology Professor Gary Glover and undergraduate Jermaine Archie of Stanford; Professor Paula Tallal and graduate student Kala

Lakshiminarayanan of Rutgers University; and former Stanford psychology Professor John Gabrieli, who recently became associate director of MIT's Athinoula A. Martinos Center for Biomedical Imaging.

It is well known that formal musical training affects how deeply people appreciate music, Gabrieli said. "This is the first example showing how musical training alters how your brain processes language components," he said. "It shows how important split-second timing is for understanding language—if you're bad at it, you're at risk of becoming a bad reader. But what's important is that people are not stuck with this—the study shows that with training people improved their perception of sounds. It shows that our mental capacity is amenable to experience: The brain is plastic, adaptable and trainable."

Past studies by Tallal and Gabrieli have shown that acoustical training can assist struggling young readers by helping them pick out rapid sound changes within syllables. Other work has shown that musical training helps people perceive sound pitches more effectively and increases verbal memory, Gaab said. But no one, she explained, has investigated *why* musical training helps do this.

The findings reveal, for the first time, that musical experience improves the way people's brains process split-second changes in sounds and tones used in speech, and consequently, may affect the acoustic and phonetic skills needed for learning language and reading.

"This is important because it lays the framework for a series of studies on how music might help children," Gaab said. "We were very surprised that musicians had a big difference" in how efficiently they processed split-second changes within syllables compared to non-musicians.

Comparing musicians and non-musicians

In the first study, researchers took 28 adults, divided into musicians and non-musicians, who were matched for age, gender, intelligence and general language ability. Musicians in the study were required to have started playing an instrument before the age of 7, to have never stopped playing and to have continued to play several hours a week. When musicians play, Gaab said, they must actively distinguish between sounds and their order, and adjust as necessary.

Non-musicians in the study had to be native English speakers with minimal experience studying non-tonal foreign languages such as Spanish. People who had studied a tonal language such as Mandarin were not included.

During the experiment, participants listened to pairs of syllables such as ba-da, ba-wa and ga-ka, and noted if each syllable in the pair sounded the same or different. Depending on how they performed, the scientists made the task increasingly difficult by using syllables that sounded more and more alike. Musicians outperformed their non-musician peers in how quickly and accurately they perceived these rapid changes, Gaab said.

In the second experiment, researchers used functional magnetic resonance imaging (fMRI) to find out whether musical training changes the way the brain processes sound. The fMRI scanning machines, which look like beds that slide into tubes, normally are used to check for brain injuries or tumors. With slightly different software they can be used to measure which regions of the brain are active by looking for changes in blood oxygenation, a process that occurs in parts of the brain where the neurons are active.

Forty people, evenly divided into musicians and non-musicians, listened to three-tone sequences made from different combinations of low and high pitches. Participants had to reproduce the order of the tones they heard by manually pressing buttons on a panel.

Musicians once again beat the non-musicians with this task. "We were surprised that musicians could do it almost perfectly," Gaab said. Musicians got the fastest tone sequences right at least 85 percent of the time, compared to non-musicians who hit a 50-percent average. They also could replicate the sequences a lot faster. "Non-musicians needed to make a lot more effort—their brains were not as finely attuned."

According to Gaab, musical training appears to alter the ability of the brain's language areas to process pitch and timing changes that are common to perceiving both words and music. "The brain becomes more efficient and can process more subtle auditory cues that occur simultaneously," she said.

For the researchers, a better understanding of how the brain learns and maintains language and how to put this knowledge into practice will be a key goal for future research into language development, dyslexia and age-related cognitive decline.