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MUSIC LESSONS:
NEW RESEARCH INTO LEARNING, MEMORY, AND MOVEMENT

Findings underscore importance of music education for hearing-impairment, language, and motor skills

CHICAGO — New studies released today explore how musical training — and its repetitious acts or movements — affects sensory input, and also suggest that day-to-day skills, such as movement and language, are shaped by learning and memory. The research, which supports the "practice makes perfect" mantra, suggests that the building block of musical education is indeed repetition, pointing to potential diagnostic and treatment options for a number of hearing and language disorders. It was presented at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

Today's new findings show that:

- What people hear is largely determined by life experience. Even when an individual is effectively deaf, our brains, trained from life-long learning and memory, can detect subtle differences in familiar sounds (Markus Engelmann, abstract 70.9, see attached summary).
- Musical training boosts higher-level hearing and strengthens hearing-specific cognitive abilities. These findings suggest musical training can help alleviate deficits in how the brain interprets sound, a leading contributor to language and literacy disorders affecting more than 10 percent of children in developed countries (Dana Strait, abstract 451.12, see attached summary).
- In a study comparing highly trained musicians and non-musicians in loud environments, musicians understood speech better and were less bothered by background noise (Nina Kraus, PhD, abstract 451.20, see attached summary).
- The longer musicians have trained, the better their nervous systems reflect their specific motor skills, much as if their years of practice left a mark directly on their brains (Reinhard Gentner, abstract 307.12, see attached summary).

"Today's findings establish the pervasive impact of musical experience on brain development," said press conference moderator Mark Tramo, MD, PhD, of Harvard Medical School and an expert on music and the brain. "The research underscores the significant promise of musical training in strengthening key cognitive and auditory skills."

This research was supported by national funding agencies, such as the National Institutes of Health and the National Science Foundation, as well as private and philanthropic organizations.

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Abstract 70.9 Summary

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Training and Experience Influence Hearing

Hearing-impaired professional musicians can still identify sour tunes

New research shows that the musically trained brain can detect whether harmonies are subtly off-key, even when an individual is effectively deaf, because auditory acuity is determined in part by life experience. The study, conducted in Germany, examined the ability professional musicians and factory workers to distinguish musical chords that were in-tune from chords with a slightly mistuned pitch. The findings were presented at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

"Our research indicates that learning and memory play a decisive role in the hearing process," said Markus Engelmann of Friedrich Schiller University at Jena, one of the study authors. "Our daily lives are influenced by a huge diversity of tones, sounds, and noises. Our brains are trained to react to these particular sounds, even if we do not consciously perceive them."

The authors tested two occupational groups that routinely suffer hearing loss: professional musicians, who are exposed to orchestra noise, and beverage industry employees, who work in loud bottling and washing plants. Participants in both groups had trouble hearing sound frequencies between 4 and 6 kHz — a tonal range near the upper limit of frequencies that can be produced by a piccolo. Auditory tests were conducted using tones within and outside the participants' deafness range. The musicians, but not the factory workers, performed well on the task.

"Our findings suggest that the typical auditory stimuli learned during a career may partially compensate for hearing deficits, as long as the sounds are specific to a person's profession," Engelmann said. These results may help clinicians evaluate hearing deficits and assess auditory handicaps.

Research was supported by the University Hospital Jena, the Interdisciplinary Center for Clinical Research, and the Employer's Liability Insurance Association for the Foodstuffs and Catering Industry.

Scientific Presentation: Saturday, Oct. 17, 1–2 p.m., South Hall A

70.9, Cortical processing of musical stimuli differs between hearing impaired professional musicians and industrial workers

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TECHNICAL ABSTRACT: The number of hearing impaired professional musicians is continuously increasing. Many of the musicians, however, are able to play their instruments without any mistake, though they are handicapped while conversing in a low voice, watching TV or using cellular phones. To test, whether learning of specific professional sounds could at least in part compensate the hearing deficits, we recorded auditory evoked potentials (AEP) to piano chords in hearing impaired professional musicians and compared it with AEP in industrial workers with similar hearing deficits and the same musical stimulation. 10 hearing impaired musicians aged 28-68 years and 20 hearing impaired workers from the beverage industry at same ages participated in our study, all suffering from a PTS of about 40 dB in the high frequency range. Stimuli were series of in-tune and -30 cent mistuned piano chords either at mid-frequency (C1) or at high-frequency (C3) ranges. In each series 200 stimuli were presented randomly according to the oddball paradigm (in-tune to mistuned = 4:1) at an intensity of 65 dB SPL. The EEG was recorded from 31 electrodes with the Brain Vision™ system. We analyzed the components N1 and P2 and the MMN. Professional musicians in all series of stimulation (both C1 and C3) identified the mistuned stimuli. N1 to mistuned stimuli was significantly earlier (109.4±9.8 ms vs. 121.6±12.1 ms in-tune chords) and P2 to mistuned stimuli was significantly smaller (7.7±2.8 µV vs. 5.0±2.2 µV in-tune chords). A typical MMN to mistuned stimuli was observed after mid-frequency and after high-frequency stimulation, though there was a hearing deficit in the high-frequency range. Industrial workers told that they were able to recognize any different noise within their machines; however, they were unable to discern the mistuned piano chords. Nevertheless, MMN could be recorded both after C1 (190.7±84.8 µVms vs. 279.6±132.9 µVms) and after C3 stimulation (182.4±89.7 µVms vs. 253.2±92.7 µVms).We assume that learning of typical auditory stimuli during career plays an important role and seems to be able to compensate partially the hearing deficit as long as stimulation is performed with profession-specific stimuli. These data are relevant for the evaluation of hearing deficits and the assessment of auditory handicaps.

Abstract 451.12 Summary

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Musical Training Enhances Auditory Attention and Perception

Congenital, developmental and acquired brain diseases could be improved with music training

Musical training boosts auditory capacities, such as those commonly deficient in children and adults with speech and language disorders, according to new research. Musicians often have auditory attention and perception advantages because musical practice requires interactive participation with complex sounds. These findings were presented at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health. The results could be used in the future to help people with developmental dyslexia and aphasia caused by stroke.

"Our results show strengthened brain mechanisms in musicians that may make them stronger and more perceptive listeners," said Dana Strait, a researcher at Northwestern University's Auditory Neuroscience Lab and lead author on the study. "Therefore, musical training might lessen the impact of auditory-based cognitive deficits."

In this study, the researchers administered auditory and visual trials to 15 adults with extensive musical training and 15 with little or no training. The musicians performed better on tests of auditory attention and backward masking — the masking of one sound by another that comes after it. There was less difference in performance between the two groups on simpler listening tasks, such as a basic hearing test.

Deficits in how the brain interprets sound contribute to language and literacy disorders, affecting more than 10 percent of children in developed countries. By strengthening cognitive abilities that control auditory processing, these deficits may improve.

Research was supported by the National Science Foundation Science of Learning Centers Program.

Scientific Presentation: Monday, Oct. 19, 4–5 p.m., South Hall A

451.12, Musical experience shapes top-down auditory mechanisms: Evidence from masking and auditory attention performance

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TECHNICAL ABSTRACT: Long-term experience, such as language and music, significantly modulates lower-level auditory function, likely via the corticofugal system. Musicians demonstrate more efficient subcortical processing of music, speech and emotionally expressive sounds, adding to a growing body of research indicating that effects of musical practice on the nervous system are not specific to musical skills. More work is necessary to tease apart mechanisms driving such enhancements in musicians. Do perceptual abilities in musicians lead to cognitive enhancements via feed-forward mechanisms or do well-developed cognitive mechanisms fine-tune preceding structures via corticofugal mechanisms?

Cognitive abilities affect a subset of perceptual measures, including backward masking and auditory and visual attention. Other measures, such as simultaneous masking, are more reliant on feed-forward processing, with thresholds determined by precision in sensory structures. In order to determine effects of musical experience on perceptual and cognitive mechanisms, we administered a battery of perceptual and cognitive tests to 15 adult musicians and 15 non-musicians addressing backward and simultaneous masking thresholds, auditory and visual attention and non-verbal I.Q. All subtests employed an identical response paradigm, visual cues, and response feedback (see Moore et al., 2009), the paradigm being a cued, three-interval, three-alternative forced choice presented as an animated computer game.

Musicians performed a subset of tasks with greater proficiency than non-musicians, including backward masking and auditory attention. Other tasks, such as simultaneous masking and visual attention, were not related to musical experience. These results indicate strengthened cognitive mechanisms in musicians that may drive perceptual auditory-specific enhancements in a top-down manner. Musical training appears to strengthen higher-level mechanisms that, when impaired, relate to cognitive deficits such as auditory processing disorder, specific language impairment and developmental dyslexia. Musical training may therefore serve to lessen the impacts of a variety of cognitive deficits by strengthening the corticofugal system for hearing.

Abstract 451.20 Summary

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Musicians Are Better Listeners at Cocktail Parties

Research shows musical training enhances ability to hear speech in challenging listening environments

According to new research, musicians have faster and more finely tuned neural responses to features of speech embedded in noise. These advantages result in the so-called "cocktail party effect" — the ability to focus attention on one person's speech among others' speech, music, and other sounds in noisy environments. The findings were presented at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

"Musicians rely on specific musical events within a rich patchwork of melodies and harmonies, and over the course of their musical training, they become adept at separating and following the sounds of instruments and melodic lines," said the study's senior author Nina Kraus, PhD, at Northwestern University. "Knowing this, we predicted that this skill would transfer to speech perception in noise."

To investigate, the researchers compared auditory test performance and electrical brain responses in highly trained musicians and non-musicians. The musicians understood speech better and had stronger brain responses.

"Our results imply that musical training enhances the ability to hear speech in difficult listening environments by strengthening the underlying brain response to acoustic features," Kraus said.

These results underscore the benefits of music education. It has already been established that older adults, the hearing impaired, and children with language-based learning problems have particular difficulty perceiving speech in the presence of background noise. These findings suggest that musical training may have therapeutic benefits for children and adults with learning and communication disorders.

Research was supported by the National Science Foundation Science of Learning Centers Program.

Scientific Presentation: Monday, Oct. 19, 3–4 p.m., South Hall A

451.20, Biological Bases for the Musician Advantage for Speech-in-Noise
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TECHNICAL ABSTRACT: There is increasing interest in the effect of musical experience on the nervous system for skills other than music. Professional musicians demonstrate finer auditory perceptual abilities for not only music-related sounds but also speech. Furthermore, extensive musical experience fundamentally influences the subcortical encoding of both temporal and spectral acoustic features important for both music and speech. Musicians have lifelong experience parsing melodies from background harmonics, a musical task akin to speech perception in noise, and can better segregate concurrently presented sounds. In order to investigate the effect of musical experience on speech perception in noise, we measured both behavioural and neurophysiological responses to speech in noise in a group of highly trained musicians who began their training before the age of seven and a group of nonmusicians who had less than three years of formal training. Musicians outperformed the nonmusicians on standardized measures of speech-in-noise perception (HINT) and exhibited enhanced temporal and spectral encoding of the eliciting speech in noise. Specifically, musicians demonstrated faster neural timing and enhanced precision of subcortical phase-locking to the harmonics of speech in the presence of background noise. Furthermore earlier response timing and improved phase-locking were related to better performance on HINT. Our findings suggest that musical experience contributes to better neural synchronization which limits the degradative effects of background noise on subcortical representation of speech sounds and provides a biological explanation for musicians' enhancement for speech perception in noise.

Abstract 307.12 Summary

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Musicians' Skills Imprinted on the Brain

Musical motions occur when nervous systems stimulated

The longer a musician practices an instrument, the better his nervous system will reflect the specific motor skills employed, according to new research. The study was presented at Neuroscience 2009, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

Exactly how motor skills are stored in the nervous system is still largely unknown. Scientists previously thought that the brain generates finger motions through a combination of movement patterns in the brain's cortex. In this new study, the researchers tested the hypothesis that neuromuscular modules — structures in the nervous system that simplify the signals that control muscles — store motor skills.

Fifteen right-handed professional musicians (nine violinists and six pianists) and 17 musically untrained participants took part in the study. A sensor glove recorded small finger motions and was used under two conditions. In one, both groups performed voluntary movements, simply grasping objects of different shapes or playing musical instruments. In the other, transcranial magnetic stimulation (TMS), a painless and non-invasive stimulation of the brain, was used to evoke finger movements while the person relaxed.

The results showed that when the musicians' bodies were relaxed but their brains were stimulated, they still made instrument-playing motions better than non-musicians.

"The longer musicians had trained, the better their nervous systems reflected their motor skills — as if, over the years, the violin or piano had left its mark directly on the brain," said Reinhard Gentner of the Department of Neurology in the University of Wuerzburg, and lead author of the study.

Research was supported by the University Research Funds of the University of Wuerzburg.

Scientific Presentation: Monday, Oct. 19, 10:45–11 a.m., Room N228

307.12 Musical Performance Skills Are Imprinted in Modular Representations of Finger Movements

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TECHNICAL ABSTRACT: It remains unknown how motor skills are stored in the nervous system. Previously, it was proposed that flexible finger motions are generated through the combination of motor synergies involving cortical neuronal elements. Here we test the hypothesis that this modular neuronal architecture adapts to support specific motor skills, whose formation requires long term training. Finger movements after TMS over the left primary motor cortex (1.3xRMT stimulation intensity, 36 randomly chosen stimulation sites, 15 stimuli per site) were recorded with a sensor glove (10 sensors, left handed) in 15 right handed skilled musicians, 9 violinists and 6 pianists (3 males, age 25.9±2.6 y). Seventeen neurologically healthy participants (4 males) matched for age (24.8±3.8 y) and handedness ("non-musicians") served as control group. Kinematic synergies were extracted using principal component analysis of finger motions evoked by TMS. Four synergies explaining >90% of the data variance were used to reconstruct the time course of active instrumental playing and grasping movements (51 different objects) by offline linear combinations. A correlation coefficient between the reconstructed and the active conducted movement served as an index of reconstruction quality. While reconstruction quality of grasping movements was similar between all groups (F=0.38, p=0.68), reconstruction of violin playing movements was superior (p<0.001) in violinists (r=0.69±0.09) with respect to non-musicians (0.64±0.09). Furthermore, violin instrument playing was best reconstructed from synergies derived from violinists and piano playing from pianists' synergies (ANOVA, instrumental performance reconstruction x instrumental education, F=14.1, p < 0.001), suggesting surprising specificity for the taxonomic group of movements. Reconstruction quality correlated with the duration of cumulated training-exposure (violinists: r=0.69, p=0.04; pianists: r=0.79, p=0.06), but not with the recent training history. These findings underline that cortico-muscular synergies may be building blocks of movements. Adaptive synergies may be considered a prime candidate of a neuronal storage device for experience-dependent skills.