Abstracts from the Literature

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Reviewer's note: Since the inception of this column six years ago, my philosophy has been to provide readers with a representative and diverse sample of current arts-medicine articles. Thanks to a seemingly neverending stream of manuscripts submitted to a wide variety of journals, I have been able to maintain this practice. However, this issue's column will depart from tradition and "feature" several articles with a common theme. In the past three years, more than 150 scientific papers have been published on a single topic—the neurobiology of music. A few of these have been reviewed in previous columns, but for this issue I will devote most of my space to reviewing six papers that focus on the specific issue of differences between the brains of professional musicians and those of amateur musicians and nonmusicians. The topic is both fascinating and complex and is far from being answered completely at this writing. The authors are affiliated with diverse institutions, many of them international. The concluding two reviews mark a return to my traditional practice of bibliographic diversity.

Gaser C, Schlaug G: Brain structures differ between musicians and nonmusicians. *J Neurosci* 2003;23:9240–9245.

From an early age, musicians learn complex auditory and motor skills, including the translation of visually presented musical symbols into complex, sequential finger movements, improvisation, memorization of long musical phrases, and identification of tones without the use of a reference tone. They practice these skills extensively from childhood throughout their entire careers. Playing a musical instrument typically requires the simultaneous integration of multimodal sensory and motor information with multimodal sensory feedback mechanisms to monitor performance. The authors examined 20 professional keyboard musicians and matched groups of 20 amateur musicians and 20 nonmusicians. Using a voxel-based morphometric magnetic resonance imaging technique, they found gray matter volume differences in motor, auditory, and visual-spatial brain regions; these included primary motor and somatosensory areas, premotor areas, anterior superior parietal areas, and the inferior temporal gyrus bilaterally. Although some of these multiregional differences could be attributable to innate predisposition, the authors believe they may represent structural adaptations in response to long-term skill acquisition and the repetitive rehearsal of those skills. This hypothesis is supported by the strong association they found between structural differences, musician status, and intensity of practice, as well as by many published animal studies.

Lee DJ, Chen Y, Schlaug G: Corpus callosum: musician and gender effects. *NeuroReport* 2003;14:205–209.

In a previous investigation, the authors found that musicians have a significantly larger anterior corpus callosum (CC). This study extends the results with a different sample (56 right-handed professional musicians and 56 age- and handedness-matched controls). Again using magnetic resonance brain imaging, they found a significant gender × musicianship interaction for both anterior and posterior CC sizes; male musicians had a larger anterior CC than nonmusicians, while females did not show a significant effect of musicianship. This finding suggests that male musicians may develop greater interhemispheric connections and increased hemispheric symmetry between motor areas and other frontal brain regions. The early commencement of intensive instrumental training during critical time periods of callosal development may trigger these differences. The lack of a significant effect in females may be due to a tendency for a more symmetric brain organization and a disproportionately high prevalence of absolute pitch (AP) among females. The authors found no statistically significant effect of AP for either anterior or posterior CC size within the male or female musician cohorts. Although a direct causal effect between musicianship and changes in midsagittal CC size cannot be established, the authors feel that the early onset and continuous application of bilateral motor training serve as an external trigger to influence midsagittal CC size through changes in the composition and myelinization of CC fibers, with implications for interhemispheric connectivity.

Lopez L, Jürgens R, Diekmann V, et al: Musicians versus nonmusicians. A neurophysiological approach. *Proc Natl Acad Sci USA* 2003;999:124–130.

The authors studied 10 musicians and 10 nonmusicians, presenting them with auditory stimulation (tone, chord, arpeggio, Mozart and Bach melodies) and recording both magnetic and electrical brain responses. A clear N1 response (primary auditory cortex) was recorded for all test paradigms in all subjects. An early process, mismatch negativity (MMN), was observed in all subjects in response to note, chord, and

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arpeggio test segments, with a significant difference between the two test groups. The MMN process is a deflection that occurs in the auditory evoked response at a latency of about 200 msec whenever a deviance is inserted randomly into a series of otherwise equal stimuli. Both test groups showed clear MMN in all paradigms, with larger amplitudes in the musician group. P300 auditory evoked responses also were recorded, and the influence of musicality in this parameter was strongest in the arpeggio and Bach melody segments. While MMN and P300 amplitude differences were statistically significant between the two test groups, N1 peak responses showed no such differences. The musician group also had significantly shorter peak latencies for both MMN and P300 responses. The authors hypothesize that each future tone (or tone set) is predicted by a parallel process and then offered for comparison with the incoming tones. The advantage of musical training is more evident in the complex test sequences, whereas responses to simpler ones do not discriminate between the two test groups, presumably because of a musician's implicit knowledge of basic tonality rules.

Münte T, Nager W, Beiss T, Schroeder C, Altenmüller E: Specialization of the specialized: electrophysiological investigations in professional musicians. *Proc Natl Acad Sci USA* 2003;999: 131–139.

Three event-related brain potential (ERP) studies examining the processing of auditory stimuli by professional musicians compared with nonmusicians are reviewed. In the first study, string instrument players and nonmusicians directed attention to one of two streams of auditory stimuli characterized by a specific pitch. Musicians showed a prolonged ERP attention effect, the late portion of which was more frontally distributed than was that of the nonmusicians. In the second study, the authors investigated auditory spatial processing in conductors, pianists, and nonmusicians. Analysis of ERPs to the deviant sounds coming from an unattended direction reveals mismatched negativity (MMN). Nonmusician controls demonstrated minimal MMN, whereas pianists had a considerable amount. In conductors, an intermediate MMN was followed by a positive deflection. Additionally, only the conductors showed behavioral selectivity of sound sources located in the peripheral auditory space. Finally, a group of drummers was compared with woodwind players and nonmusicians in a passive listening test, where a continuous drum sequence was manipulated so that some beats were anticipated by 80 msec. The drummers demonstrated a mismatch response not only for the anticipated beats, but also for the subsequent beats, suggesting a more complex representation of the temporal aspects of stimulus sequence in this subject cohort. The studies suggest qualitative differences of the neural correlates of auditory processing between musicians and nonmusicians, deeply engraved processing strategies shaped by years of musical experience and, even more, by the specific training of a musician.

Gaab N, Schlaug G: Musicians differ from nonmusicians in brain activation despite performance matching. *Proc Natl Acad Sci USA* 2003;999:385–389.

The authors compared brain activation patterns in a group of musicians and a group of nonmusicians (matched in performance score to the musician group) during a test of pitch memory. Functional magnetic resonance imaging was employed for data acquisition. Both groups showed bilateral activation (left more than right) of the superior temporal gyrus, supramarginal gyrus, posterior middle and inferior frontal gyri, and superior parietal lobe. Musicians showed greater right posterior temporal and supramarginal activation, whereas nomusicians had greater activation of the left secondary cortex and in a portion of the anterior segment of the planum temporale. Results are interpreted as indicating perceptual and cognitive processing differences between musicians and nonmusicians, because performance scores and measures of hemispheric asymmetry were similar between the two groups. Although musicians seemed to use more short-term auditory storage centers, nonmusicians relied more on early perceptual brain regions within the superior temporal lobe to solve the pitch memory task with similar performance.

Lotze M, Scheler G, Tan H-RM, et al: The musician's brain: functional imaging of amateurs and professionals during performance and imagery. *Neuroimage* 2003;20:1817–1829.

Since professional musicians routinely employ imagery in training, the investigators wished to determine if increased motor imagery experience might result in brain activations manifested during imagined motor performances. They compared activation maps of 8 professional and 8 amateur violinists during actual and imagined performances of Mozart's G major concerto; execution and imagination of left-hand fingering movements of the first 16 bars of the piece were performed. Electromyographic (EMG) recording and feedback were used, in conjunction with functional magnetic resonance imaging. Professional musicians generated higher EMG amplitudes during movement execution and showed focused cerebral activations in the contralateral primary sensorimotor cortex, the superior parietal lobes bilaterally, and the ipsilateral anterior cerebellar hemisphere. That professionals exhibited higher activity of the right primary auditory cortex may reflect an increased strength of audio-motor-associated connectivity. During execution of musical sequences in professionals, a higher economy of motor areas frees resources for increased connectivity between the finger sequences and auditory as well as somatosensory loops, which may account for the superior musical performance. Professionals also demonstrated more focused activation patterns during imagined musical performance. However, the auditory-motor loop was not involved during imagined performances in either musician group.

McCormack M, Briggs J, Hakim A, Grahame R: Joint laxity and the benign joint hypermobility syndrome in student and professional ballet dancers. *J Rheumatol* 2004;31:173–178.

This paper examines the prevalence of hypermobility and the benign joint hypermobility syndrome (BJHS) in dancers, and addresses the possible effects of BJHS on a dance career. Subjects for measurement were 149 students and 71 professional dancers from London's Royal Ballet School, and Ballet Company, plus a control group of 36 London teenagers and 31 adults. Data included anthropomorphic variables, the Beighton Scale for hypermobility, and clinical features constituting BJHS. Odds ratios (ORs) for hypermobility and BJHS were calculated, and the prevalence and distribution of BJHS were examined. Both hypermobility and BJHS were common in male and female dancers when compared with controls. The prevalence of BJHS was found to decline both from the student to the professional, and within the ballet company from the corps de ballet to principal dancers. Odds ratios for BJHS in student dancers were significant, but not so in professionals. Arthralgia was common in dancers, reported more often in males. In females, pain was reported most by dancers with other features of BJHS, especially stretchy skin. The fall in prevalence, and the greater reporting of arthralgia with other BJHS features by young female dancers, suggests that BJHS may have an important negative influence, and this may have implications for dance training. In males, pain reporting and injury seem to be related to factors other than BJHS.

Selby JC, Gilbert HR, Lerman JW: Perceptual and acoustic evaluation of individuals with laryngopharyngeal reflux pre- and post-treatment. *J Voice* 2003;17:557–570.

Thirteen individuals with laryngopharyngeal reflux (LPR) caused by acid irritation and diagnosed by videostroboscopic laryngoscopy were treated with an 8–10-week course of dietary modifications, proton pump inhibitor medication, and speech therapy. The effect of treatment on perceptual ratings of voice quality and frequency and intensity measures was examined. Relationships between perceptual and acoustic parameters were assessed descriptively. Results showed a small but significant improvement in the perception of voice quality post-treatment. No significant difference was found between pre- and post-treatment means for any of the acoustic measures, except for harmonics-to-noise ratio in all vowels. Descriptive analyses showed some association between perceptual ratings and acoustic measures. The overall severity of voice quality of the subjects was judged to be mild both pre- and post-treatment. Subjects with severe LPR may demonstrate greater changes in voice quality and acoustic measures from pre- to post-treatment.