

Oral presentation

Structural, functional and perceptual differences in the auditory cortex of musicians and non-musicians

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The perceived musical pitch of harmonic complex tones, such as instrumental sounds, was observed to vary largely by up to three or four octaves, when the same sound was presented to different individuals. For example, if the 5th, 6th to the 7th harmonic of 500 Hz was played, the perceived pitch ranged between one-line B and four-line F sharp. Some subjects recognized dominantly the fundamental pitch, whereas others perceived dominantly single harmonics of the complex sounds. To quantify psychoacoustically these large perceptual differences, as earlier reported by Hermann von Helmholtz, we performed a pitch test using tone pairs of complex tones in a large sample of 306 professional musicians, 66 amateurs and 48 non-musicians. Participants were asked to find out the dominant direction of pitch shift. Overall, we observed a large bimodal distribution which enabled the classification in fundamental and spectral pitch listeners.

In a subgroup of 87 subjects, magnetic resonance imaging (MRI) and magneto encephalography (MEG) studies demonstrated a strong neural basis for both types of pitch perception irrespective of musical aptitude. The fundamental pitch listeners exhibited a pronounced leftward-asymmetry of gray matter volume and functional activity in the pitch-sensitive areas of lateral Heschl's gyrus whereas in contrast, spectral pitch listeners exhibited a corresponding pronounced rightward-asymmetry.

The relative hemispheric lateralization in relation to perceptual preference was observed in both musicians and non-musicians whereas the absolute size of the neural HG substrate depends on musical ability. The gray matter volume of Heschl's gyrus was twofold larger in professional musicians as compared to non-musicians. Furthermore, the magnitude of the auditory evoked P50 m activity in response to harmonic complex tones as measured by

MEG was fivefold larger in professional musicians as compared to non-musicians. The gray matter volume reflected musical aptitude as measured by the Advanced Measure of Music Audiation (AMMA) test from Edwin E. Gordon. Musical aptitude stabilizes prior to the outset of intensive musical education at the age of about nine years. In contrast, the P50 m magnitude only correlated strongly with musical long-term practice. Therefore, our data suggest a functional-structural separation of musical long-term-training and musical aptitude in the auditory cortex of musicians and non-musicians.

As a further important result of this study, the perceptual, structural and functional asymmetry was strongly linked to physical sound properties and musical instrument preference. The left auditory cortex (AC) is sensitive to short timescales (<50 ms), and the right AC to slower timescales (>200 ms). The fundamental pitch (f_0) of an instrumental sound ($f_0 > 25$ Hz) reflects its periodicity $T = 1/f_0$, corresponding to time segments shorter than 40 ms. Thus, the existence of two pitch centers may facilitate the extraction of fundamental pitch in left AC and spectral pitch in right AC. Indeed, most professional musicians perceive simultaneously both fundamental and spectral pitch from an ambiguous tone, and the subjective differences are rather relative than absolute. As a consequence, fundamental pitch listeners may prefer impulsive short tones and therefore usually prefer to perform music in a more percussive manner or to play percussive and high-pitched instruments (e.g. drums, piano, guitar, trumpet or flute). In contrast, spectral pitch listeners may prefer slower sustained tones including characteristic spectral information in form of formants or vowels in the singing voice and therefore usually prefer singing or to play lower-pitched melodic instruments (e.g. bassoon, saxophone, french horn, organ or double bass).

Overall, it is likely, that both magnitude and asymmetry of lateral HG, and related perceptual mode, may have impact on preference of timbre, tone and size of particular musical instruments and in particular on musical performance.

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