ABSTRACT

Hearing is a crucial sense enabling humans to integrate into external environment and effecting the quality of life. Wide range of studies were carried out to investigate its functioning, examination methods, preservation, and treatment. Therefore, our aim was to contribute to spreading current knowledge of effect of hearing pathologies and aging on the auditory system.

Asymmetric or unilateral hearing loss (AHL) may cause irreversible changes in the processing of acoustic signals. We examined peripheral and central auditory functions of 25 subjects with AHL resulting from vestibular schwannoma, and compared them to those from 24 normal-hearing (NH) controls that were matched with the AHL subjects in mean age and hearing thresholds in the healthy ear. Besides the basic hearing threshold assessment, the tests comprised the detection of tones and gaps in a continuous noise, comprehension of speech in babble noise, binaural interactions, difference limen of intensity (DLI), and detection of frequency modulation (FM). For the AHL subjects, the selected tests were performed separately for the healthy and diseased ear. In the second part of the research, we focused on changes induced by aging, presbycusis and tinnitus, which are detectable by magnetic resonance imaging (MRI). Aging negatively influences the structure of the human brain including the white matter. We used fixel-based morphometry to study age-related changes in pathways connecting several parts of the central auditory system (inferior colliculus, Heschl's gyrus, planum temporale) and pathways connecting these structures with parts of the limbic system (anterior insula, hippocampus and amygdala). In addition, we were interested in the extent to which the integrity of these pathways is influenced by hearing loss and tinnitus. Tractographic data were acquired using a 3 T MRI in 79 volunteers. The subjects were divided into several groups based on their age, auditory thresholds and presence of tinnitus. Fixel-based analysis was used for the detection of changes in the following three metrics: logarithm of fiber cross-section, fiber density, fiber density and cross-section. Two modes of analysis were used: whole brain analysis and targeted analysis using fixel mask, corresponding to the pathways connecting the aforementioned structures.

We observed that binaural speech comprehension, gap detection, and FM detection abilities were dominated by the healthy ear and were comparable for both AHL and NH group. The AHL subjects were less sensitive to interaural delays, however, they exhibited a higher sensitivity to sound level, as indicated by lower DLI and a higher sensitivity to interaural intensity difference. Correlations between the individual test scores indicated that speech comprehension by the AHL subjects was associated with different auditory processing mechanisms than for the control subjects. A significantly negative effect of aging was present for all fixel-based metrics, namely the logarithm of the fiber cross-section (7 % fixels in whole-brain, 14 % fixels in fixel mask), fiber density (5 % fixels in whole-brain, 15 % fixels in fixel mask), fiber density and cross

section (7 % fixels in whole-brain, 19 % fixels in fixel mask). Expressed age-related losses, exceeding 30 % fixels, were particularly present in pathways connecting the auditory structures with limbic structures. The effect of hearing loss and/or tinnitus did not reach significance.

The data suggest that AHL influences both peripheral and central auditory processing abilities and that speech comprehension under difficult conditions relies on different mechanisms for the AHL subjects and for NH controls. Regarding the MRI study, our results show that although an age-related reduction of fibers is present in pathways connecting several central auditory structures, the connections of these structures with limbic structures are even more reduced. To what extent this fact influences the symptoms of presbycusis, such as decreased speech comprehension, especially in noise conditions, remains to be elucidated.